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CHAPTER EIGHT

Appraisal of freight projects and policies

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Contents

Abstract

Freight transport systems are facing ever-growing demand and increasingly stringent requirements. Governments are pressured to develop new policies and fund new projects that drive forward the freight transport systems. We provide an overview of typical evaluation approaches used for freight transport policies and projects, from the public policy perspective.

We make a simple introduction to the freight transport system, including the most representative agents and components. We introduce a basic framework, briefly reviewing some key literature on the topic and describe the salient features of the state of freight transport appraisal practice today. We also introduce the main freight transport modeling approaches that support project appraisal. We distinguish three types of freight projects according to their geographical scope—global, national and local level—as the appraisal techniques differ. Cost-Benefit Analysis is the prevalent technique in global level projects and very common in national level projects. Multicriteria Analysis type approaches dominate at the local level. Finally, we identify research challenges related to appraisal of freight transport projects and policies.

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1. Introduction

Freight transport is the lubricant of the modern world, enabling the movement of goods—raw material, and intermediate or end products—between many distant locations. For example, the emergence and gradual spread of the globalization phenomenon was spurred by advancements in the freight transport sector. In the mid-1950s, Malcom McLean, an owner of a trucking company, was struggling with the high costs and transit times of transport services (Mayo and Nohria, 2005). Notably, the transhipment times between ships and trucks at the port was painfully long. By that time, goods were carried in bulk on ships' decks and platforms. Eventually, Malcom McLean came forward with the idea of using a box—the future maritime container—to transport the goods. The goods would be loaded into the box, which would be the only object to be handled between vehicles along the journey. On 26 April 1956, the ship Ideal X made its maiden voyage from Port Newark to Houston in the USA. It carried 58 metal container boxes (35 ft. long). McLean's fundamental insight about the container was that a transport company's mission was moving freight—rather than moving vehicles. The consequences were overwhelming: (un)loading times of ships were compressed up to 85% and handling costs at ports were reduced up to 95% (Levingson, 2006). What is really interesting with this story is that the breakthrough did not rest on the container itself. McLean established an entirely new paradigm of moving freight, which included the development of new vehicles (e.g., container ships, trucks or wagons), ports and terminals, technology (e.g., cranes) or organizational and operational improvements among the shippers. In the ensuing years, standardization bodies, such as the International Standardization Organization, worked hard to enable worldwide interoperability, so that a container could efficiently be carried regardless the owner, location or type of cargo. Currently, maritime containers account for approximately 60% of all world seaborne trade (Statista Research Department, 2020). In the abovementioned example, new equipment (e.g., containers, cranes, ships or trucks) opened the door for a new paradigm for the organization of freight transport services. This had great impact on the surrounding infrastructure for all related modes of transport.

With the wave of containerization behind us, what new reasons could motivate the need to have systematic appraisals of freight transport projects and policies? Freight systems have continued to evolve at an unprecedented pace, spurred by developments at multiple levels:

- Rapid digitalization of economies and societies is paving the way to new business models and markets, and to profound changes on how goods are traded and transported.
- Heterogeneous generational mix with fundamentally different values and beliefs. Younger generations are digital natives and avid on-line consumers (spurring e-commerce); whereas older generations remain faithful to the physical stores.
- Growing environmental awareness is leading consumers and policymakers demanding low carbon freight transport solutions.
- New materials and fuels are leading to the development of new low-emissions and ultra-energy efficient vehicles and equipment.
- Significant technological developments in the realm of computational power—e.g., Artificial Intelligence or Big Data Analytics—is enabling the development of enhanced tools and equipment.

As an effect of the above, freight transport systems are facing ever-growing demand and increasingly stringent requirements. The pressures to improve performance levels of supply chains, in terms of costs, speed, reliability or safety, are still increasing. Governments are pressured to develop new policies and fund new projects that could drive forward the freight transport systems. In an increasingly volatile and dynamic world, also the appraisal of freight projects and policies is becoming increasingly complex. We started this chapter with the example of Malcom McLean to demonstrate the profound impact that investments in freight transport systems may have on society. Appraisal, therefore, is potentially a daunting task, no less complex than evaluations of projects for mobility of people.

In this chapter, we provide an overview of typical evaluation approaches used for freight transport policies and projects, from the public policy perspective. We introduce a basic framework, briefly review some key literature on the topic and describe the salient features of the state of freight transport appraisal practice today. The chapter is built up as follows: Section 2 focuses on the framework including the main terminology used to denote parts of the system, freight-typical definitions of appraisal components and an outline of the main types of quantitative models used for appraisals. Section 3 provides an overview of the main approaches and issues behind appraisal at three different levels of spatial analysis: global, national and urban. Section 4 summarizes the main topics of freight transport appraisal and concludes the chapter.

We continue this chapter with an introduction of some commonly used terms and frameworks for freight policy evaluation.

2. Terms, frameworks and models

2.1 Freight transport system

The freight transport system is defined as a set of interconnected markets that together serve to have goods available for consumption everywhere around the world (Fig. 1).

There are many stakeholders who act inside this system, either by driving demand, carrying out services, investing in infrastructure or experiencing the system in an indirect way including:

– Producers and consumers. Note that manufacturers, wholesalers, retailers and private households are all producers and consumers and therefore also both senders and receivers of goods. The chain of manufacturers, wholesalers and retailers that results in the supply of a product on the market is called a supply chain. Supply chains are intertwined in many complex ways supply networks.
– Logistics Service Providers (LSPs) are frequently hired by shippers to organize logistics. This may be limited to transportation, but sometimes extends to warehousing, handling and other services. A classical role here is that of the forwarder, who organizes movements from A to B.

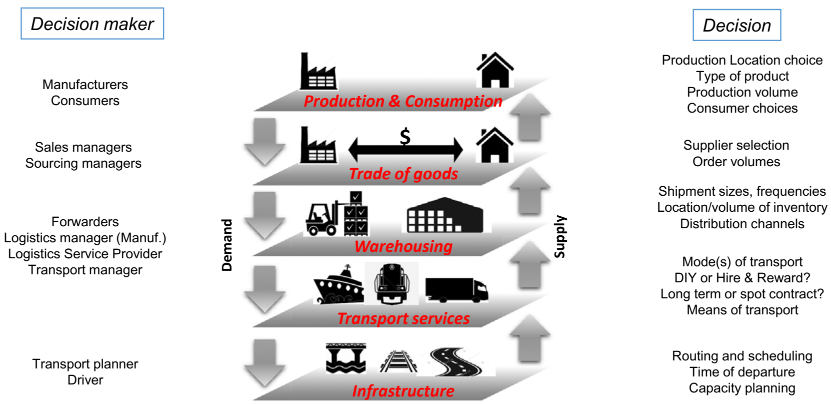

Fig. 1 The freight transport system.

– The above organizations have in common that they can contract freight transport services. In this role, they are sometimes taken together and defined as shippers.
– Carriers execute transportation services between two points or in a roundtrip. The carrier can be part of the shipper's organization (own account carrier), or of an LSP, or an independent, hire-and-reward carrier.
– Government authorities typically invest in collective goods like shared infrastructures, and regulate markets through norms and standards, access control and financial instruments.
– Indirectly, the system affects many other people via external effects (especially of social and environmental nature) of activities or via indirect economic effects.

2.2 Freight transport networks

Freight transport systems are typically operated via infrastructure networks. Over the network a wide paraphernalia of transport equipment is used to ensure the physical movement of the goods. A network is made of links within a set of nodes. A link connects two nodes. The link is a route and it is materialized in terms of a mode of transport, such as roadways, railways, airways, waterways or pipelines. Nodes can be either origins or destinations of the freight. Additionally, they may be intermediary locations in a network where the freight is handled and temporarily stored. Often, they serve as transfer points between modes of transport—i.e., links. Examples of nodes include ports, airports, terminals or warehouses. Specific equipment ensures the physical movement of the freight over the network (links and nodes) from origin until destination. On the links, each mode of transport requires specific vehicles, such as trucks, trains, aircrafts or ships. At the nodes, there is a wide diversity of devices, including cranes, forklifts, reach stackers, tractors, or platforms.

Commonly, links are owned by the government, due to their interest to the social and economic development of the regions and country, and because of sovereignty reasons. There are other reasons that justify public ownership such as the fact of some transport infrastructure, such as railways, being natural monopolies; or, when the economic rationale is dubious (e.g., very long payback terms, or uncertain demand). Large nodes, such as ports, airports or railways terminals are also typically publicly owned; although in some geographies these could be privately financed (Burns, 2015; Graham, 2018). Smaller nodes are often privately owned.

In what concerns the management of the transport network, it can be done by either public or private companies. The latter situation involves specific schemes of very long-term concessions.

In some cases, public and private entities can work together in the development (e.g., design, construction, maintenance, etc.) of a specific link or node. Such kind of cooperation is designated as Public-Private Partnership (PPP) (OECD, 2012). PPP gained widespread popularity in some regions, notably Europe, in recent decades (Roumboutsos, 2016). By way of example, at the European Union level, the majority of the PPP have been implemented in the field of transport. A PPP is defined as long-term contractual arrangements between the government and a private partner whereby the latter delivers and funds public services using a capital asset, sharing the associated risk (European Court of Auditors, 2018). PPPs become popular among policy makers and private companies. On the one hand, they allow the public sector to benefit from private sector capacities and resources, leading to increased quality of transport infrastructure development and management, for lower prices, and with faster delivery times. On the other hand, private companies de-risk their position in the project, which increases their financial and economic return, and sign a long-term and stable contract with a reliable customer.

Transport equipment is commonly owned and managed by private stakeholders. Some stakeholders are transport companies—i.e., link operators—(e.g., air transport companies, rail transport companies), while others are terminal operators—i.e., node operators—(e.g., airport handling companies or port handling operators). Other stakeholders can operate both links and nodes, such as logistic companies or freight forwarders. These stakeholders are responsible for organizing and managing the freight transport services between nodes, on behalf of the shippers or receivers. Some transport services involve one mode of transport; whereas others combine two or more modes of transport. The utilization of one mode of transport is prevalent in continental distances. Road transport is the primary mode of transport. To illustrate, at the EU level, road transport is responsible for transport of more than 80% of all goods (European Commission, 2019). The combination of modes of transport is commonly used in intercontinental transport services. In these services, sea and air transport is used to bridge the continents, while road (and, to some extent, rail) connect the port or airport with the origin or end node. Different designations can be employed to name transport services that use two or more modes of transport, namely: multimodal transport, intermodal transport, combined transport, co-modal transport or synchro-modal transport. The specific designation depends on several factors,[b] such as: organization level, types of modes of transport, or intensity of utilization. Out of the five, synchro-modal transport is arguably regarded as a most advanced concept. Synchro-modal transport is defined as the coordination of logistics chains, transport chains and infrastructure, in such a way that, given aggregated transport demand, the right mode is used at every point in time (TNO, 2011).

2.3 Impact assessment for freight projects

Here, we introduce terms that apply especially for freight transport projects. Roughly assessment follows the same line of thinking as assessments for passenger transport. The common terms for assessment are very similar. For example, direct benefits of transport policies and projects include those that can be measured at the level of transport system users. The usual approach is to measure changes in consumer surplus based on changes in (monetized) utility and on transport flows. The monetary effect of a policy is usually assessed using the price changes and transport time changes monetized using a value of transport time[c] (VOT). Indirect welfare effects, that are additional to the direct effects, could occur if there are market imperfections that prohibit impacts from being fed back to transport system users. The freight system has its peculiarities, which make the approach different in details from passenger transport appraisals. In line with the definition of the freight transport system, the appraisal includes the following interesting elements[d]:

- The value drivers of societal benefits from freight transport investments are manifold. The first, direct beneficiary in the supply chain from an improved freight transport system is the carrier, as he will experience lower costs to fulfill the contracted service.
- The carrier will consider how to use this benefit. Reduced costs may lead to increased profits. However, with very (close to perfectly) competitive carrier markets, if his competitors also profit from the improvement, the benefit will be passed on quickly to the shipper, by means of decreased transport prices. The same reasoning holds for benefits associated with increased speed of transport—the carrier may decide to use this to work more efficiently, or to provide better services.

[b] The definition of each concept lies outside the scope of this text. The interested reader is referred to Reis (2015).

[c] Further detail about the value of travel time and travel time reliability can be found in De Jong and Kouwenhoven (2020).

[d] We refer the interested reader to Blauwens et al. (2006) and Lakshmanan (2011).

- Note that travel time is not always a key requirement, but rather fulfillment of window delivery times. Often, the shipper defines specific window times for delivery. In such cases, early arrivals (i.e., shorter transit times) are not highly valued.
- Beyond the shipper lies the wider supply chain. Upstream we find the shipper's suppliers who may be impacted by a change in demand for goods and services. Downstream lies the client of the shipper, ultimately the consumer. If all these markets are perfectly competitive, the gains from transport improvement will propagate on, without any new benefits being generated.
- This propagation is not linear and has multiple branches as logistics decisions may result in a shift between routes, modes of transportation, a shift away from transportation into warehousing, a shift in demand for products, and so on.
- The benefits will not remain in the transport sector but will be transferred to transport using sectors. Besides the markets for products and services, there are important links with other markets related to, e.g., fleet investments, real estate and the capital market, which may all be affected by changes in transport prices.
- In the freight market, several imperfections can be found, which will lead to additional impacts being generated, including external effects, regulated markets for services, products or production factors, scale effects and oligopolistic market situations.
- Finally, there are intricate linkages to passenger transport systems. Consumers will undertake shopping trips, which is one of the motives of transport. The labor market will be affected by freight prices, which determines commuting patterns. Business trips are tied to production and storage locations, which may change as an effect of freight projects.

Guidelines for transport appraisal rarely include chapters specifically for freight transport. As a result, many of the above questions have received very little, or no attention in the literature.

2.4 Freight transport models

To measure the welfare effects of freight policies and projects, we need to know how these effects are built up through the markets of the transport system. This implies a comprehensive, quantifiable understanding of the different markets, the supply and demand functions in these markets and how these interact. The complexity of the many possible responses of firms to freight policies is daunting, however—a condensed summary of supply chain decisions would lead to at least 48 decisions. Therefore, practical, empirical models of the freight system focus on only a handful of these decisions (Tavasszy et al., 2019). It concerns those decisions that are immediately affected by freight policies and infrastructure projects, and include route choice, vehicle type and mode choice, use of inventories, trade and production.

Remarkably, these come from very different economic disciplines. Economic geography has produced a range of models that, in an integrative fashion, describe production, consumption and trade. The Nobel Prize winning work of Krugman (1991) provided the scientific backbone for the current range of Spatial Computable General Equilibrium (SCGE) models. The SCGE family of models uses production functions that predict demand, supply and trade of goods and services, measured in monetary terms. The Input-Output (I/O) models and regional production function models can be derived as a reduced model (Tavasszy et al., 2011). Equally rooted in neoclassical economics, but empirically developed in the research area of transportation are the discrete choice models (also developed via Nobel Prize winning work of McFadden (1981) and operationalized in Ben-Akiva and Lerman (1985)). Discrete choice models are formulated from a demand perspective, predict choice probabilities and can be applied to any fitting choice problem (Marikawa et al., 2002). The well-known gravity model lies between these two areas, as an aggregate, pragmatic empirical model of trade activities, that can be derived from both approaches.[e] We can also find mixed approaches such as the LUTI (Land Use Transport Interaction) and MRIO (Multi-Regional Input/Output) models that apply discrete choice models to predicts changes in production and consumption.

In practical freight appraisals, several combinations of these models can be used, resulting in a variation of architectures for freight transport models (Tavasszy and De Jong, 2014). We briefly introduce the dominant combinations below (Fig. 2).

Freight generation models are based on I/O models or economic aggregates (direct freight generation) and will typically not allow a prediction of the impacts of changes in the transport system on the demand or supply of goods. Advanced consumption models can be added that represent consumer or retailer behavior as a response to changes in product prices. Focusing on the geography of trade, gravity models will allow to assess

[e] Some further detail about transport models can be found in Van Nes and De Jong (2020).

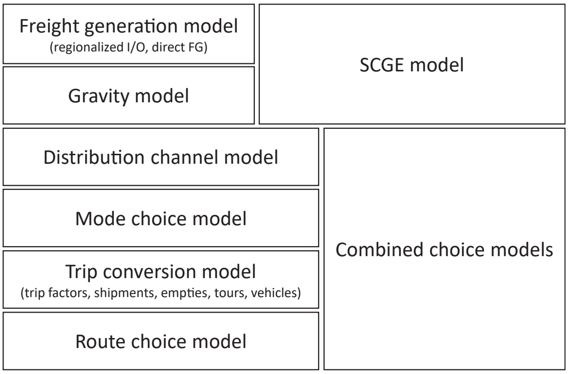

Fig. 2 Main options for composition of freight transport system models.

the impacts of policies on volumes of freight between regions, where the total volume of trade is assumed to remain stable. If one wishes to predict changes in demand and supply, SCGE models are the only viable (theoretically supported) option. Where we see different choice models applied to deal with transportation choices, these can also be combined in various forms.[f] Most freight models in the literature concern the choice of mode. Route choice models in practice are usually simplified and operate together with passenger transport models. Distribution channel choice models predict changes in the use of distribution centers and thus in total transport distances. They are relatively new but have been shown to add significantly to the price elasticity of freight transport demand. The function of trip conversion models is to convert freight flows expressed in tonnes (per year, usually) to flows expressed in vehicles. Originally, these models were using factors which were not sensitive to changes in transport prices or times, but recently, new models have emerged. These explain the choice of shipment size, tour formation (including empty trips) and the use of different vehicle types.

A full-fledged freight transport system model that takes transport price and time (generalized cost) changes as inputs may be able to predict the total welfare effect: direct effects and indirect effects will together propagate into the economy. The resulting changes in trade could also be fed back to the transport system, which would allow to assess direct effects according to the classical CBA definitions, as used in most countries.

[f] The interested reader is referred to Reiche (2017), Stinson et al. (2017), or Rich et al. (2009).

3. State-of-practice in appraisal

3.1 Relevance of geographical levels

There is a hierarchy in the spatial organization of the freight transport networks at the local, regional and global levels. The spatial dynamics of freight transport vary considerably with distance, and so does the type of projects.

- *Global networks* support the trade of all kinds of goods, including raw materials, energy products or manufactured products, among countries worldwide. Global networks connect nodes located in different continents, typically by sea and air transport or pipeline (of oil or gas). In recent years, rail services have gained increased relevance in these global networks. An example is the Eurasian Land Bridge, a flagship project of China's Belt and Road Initiative (BRI) (Box 1). In particular, global structures have been put in place to ensure projects and freight transport market evolves according to globally agreed strategic objectives. At the global level, the World Trade Organization (WTO) is the most relevant intergovernmental organization. The WTO established a framework for trade policies, supported in five principles, being: non-discrimination, reciprocity, binding and enforceable commitments, predictability and transparency, more benefits for less developed countries, and environmental protection. Supporting project funding structures include the World Bank and the regional development banks that work along the

BOX 1 The Chinese Belt and Road Initiative.

By way of example, at the global level, the Chinese Belt and Road Initiative[a] (BRI), launched in 2013 by President Xi Jinping, entails an overland Silk Road Economic Belt and the Maritime Silk Road. The plan includes creating a network of railways, energy pipelines, ports and highways. From a geographic dimension, the BRI stretches both westward—through the mountainous former Soviet republics—and southward, to Pakistan, India, and the rest of Southeast Asia. Overall, the BRI cover +65 countries, including 65% of the world's population and 40% of the global gross domestic product as of 2017 (Campbell, 2017; Chatzky and McBride, 2020). The most common estimates for the current proposed total budget for BRI are \$1 trillion and \$1.3 trillion (Rolland, 2019).

[a] Formerly known as One Belt One Road.

same principles. Some projects of global significance, like the BRI, are co-funded by multiple organizations.

- *National level networks* ensure primarily the movement of intermediary products and commodities within the regions, often originating from (or with destination to) nodes of global networks. The intermediary products are commonly moving along larger supply chains (e.g., spare parts for cars). Examples of commodities include food (e.g., beef or certain common juices), fuels or metals. National networks link together to stretch out across continents. These networks tend to make extensive utilization of land-based links, notably road transport. In the United States, the National Highway System is a network of strategic highways, including the interstate highway system and other roads (e.g., strategic highway network, or intermodal connectors) serving major airports, ports, rail or truck terminals, railway stations, pipeline terminals and other strategic transport facilities. National networks may be internationally coordinated, based on a joint vision or strategy, as is the case in Europe for the Trans-European Networks for Transport (TEN-T).
- *Local level networks* refer to those networks that serve urban regions and surrounding areas. These networks are very dense. They make use of the land base links, notably road and rail (including metropolitans, trams and others). The nodes include a myriad of locations including retail activities (e.g., supermarkets or shops), service activities (e.g., activities, hotels, restaurants or coffee shops), warehouses, or households. Cities are densely populated areas and important business districts. People acquire consumer products and service companies also tend to import and export final products. Cities are not only consumption locations, but also relevant producers of waste and other products (e.g., recycling material). At local level, a wide diversity of projects, notably within the realm of urban logistics, are being funded by public and private entities. These include urban consolidation centers, urban rail freight services, electric fleets of freight vehicles, just to mention a few.

As mentioned above, policies at national and supra-national level are strongly linked, where linkages depend on the geographical scope. Governments may establish joint "regional[g]" trade policies. Currently, there are several regional blocks worldwide, such as:

[g] This term is also often used to denote a region of the world, as opposed to the regional geographical scale in between national and local scale

- The European Union (EU) is arguably the most developed and ambitious political and economic intergovernmental union. In 2020, it has 27 member states. The EU has developed the world's largest single market area. Free trade among its members was one of the EU's founding principles. EU policies aim to ensure the free movement of people, goods, services and capital within the internal market. The EU has a Common Transport Policy, aimed at opening-up of transport markets and creating of the Trans-European Transport Network (Box 2) (European Parliament, 2020a).
- The North America Free Trade Agreement (NAFTA) is an agreement signed, in 1994, by Canada, Mexico, and the United States, creating a trilateral trade bloc in North America. One of the founding objectives of NAFTA was to eliminate barriers to trade in, and facilitate the cross-border movement of, goods and services between three members. NAFTA led to the progressive elimination of tariffs and all duties and quantitative restrictions, with a few exceptions, by 2008.
- Association of Southeast Asian Nations (ASEAN) Free Trade Area (AFTA) is a trade bloc agreement, signed in 1992, signed by the ASEAN. The ASEAN has 10 members. The AFTA aims at supporting local trade and manufacturing in all ASEAN countries, and facilitating economic integration with regional and international allies. Duty tariffs for goods originating within AFTA are being progressively eliminated.
- South American trade bloc (MERCOSUR) is an agreement signed in 1991 and 1994 between Argentina, Brazil, Paraguay and Uruguay,

BOX 2 The transport netwok that connects European Member States.

The Trans-European Transport (TEN-T) Network, an EU flagship program, aims at implementing and developing an EU-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals connecting all member states. The TEN-T Network comprises two network layers: (i) the Core Network includes the most important connections, linking the most important nodes, and (ii) the Comprehensive Network connects all European regions to the Core Network. The backbone of the TEN-T Core Network is the rail transport. A total of nine Core Network corridors crossing the EU member states are planned. The TEN-T proposed budget for the 2021–2027 period amounts to EUR 42.4 billion (European Parliament, 2020b). Individual projects generally have budgets that run into billions of Euro.

subsequently joined by Venezuela. Seven other South American countries are associate members. MERCOSUR purpose is to promote free trade and the fluid movement of goods, people, and currency. MERCOSUR includes a customs union, in which there is free intrazone trade and a common trade policy between member countries.

Methodological preferences differ at different scales. The spatial dimension of the freight network—global, regional or local—will define the country or countries of interest, the political context of decision making, the laws and regulations governing appraisal projects, the supporting quantitative models and data available, among other actors. This results in different approaches at different levels:

– At the global level, changes in trade policies, new tax regimes and megaprojects like the BRI require availability of global models for trade and transport, and assessment is found in various forms, focusing on general principles of simplified cost-benefit analysis.
– At the national level, cost-benefit analysis (CBA) approaches are practised most clearly, because of the link to national accounts and state level politics, and come with detailed guidelines (though varying by state) that sometimes prescribe sophisticated tooling or approaches.[h]
– At the local level, the approaches used become more diffused and scientifically less narrow, with MCA type approaches dominating at the city level.

We explore the usual practices at these three spatial levels in more detail in the next section.

3.2 Global level practices

Funding institutions also require appraisals before agreeing on financing a given project. At the global level, the *World Bank* is a key source of financial and technical assistance to developing countries worldwide. The World Bank does not have specific guidelines or practices regarding freight transport projects.

In order to fund a project, the World Bank institutions require a full appraisal, which covers independently economic, financial, institutional, environmental and social aspects. The purpose is to give stakeholders an opportunity to review the project design in detail and resolve any pending

[h] For comparisons of current practices within and outside Europe, we refer the reader to reports of the IASON and HEATCO projects of the EU Transport Research Program, both aimed at developing appraisal guidelines.

questions. The national governments and the World Bank review the work done and confirm the expected project outcomes, intended beneficiaries and evaluation tools for monitoring progress. The approval of a lend by the World Bank depends on the expectation of net benefits from the project. If both agree, then an agreement is reached on the viability of the project and on the post implementation monitoring program. The World Bank appraisal requires answering to the following 10 questions (Gwilliam, 2000):

1. What is the objective of the project?
2. What will happen if it is implemented, and what if it is not?
3. Is the project the best alternative?
4. Are there any separable components, and how good are they separately?
5. Who are the winners and losers?
6. Is the project financially sustainable?
7. What is the project's fiscal impact?
8. What is the project's environmental impact?
9. Is the project worthwhile?
10. Is this a risky project?

Additionally, the appraisal should follow these set of principles (Omega Centre, 2010):

1. Benefits and costs should be measured against the situation without the project.
2. All projects should be compared against alternatives, including the alternative of doing nothing.
3. If a project is expected to generate benefits in non-monetary terms the analysis has to show that the project represents the cheapest way of attaining the stated objectives.
4. Long-term economic and environmental sustainability must be assessed, taking into account the chances of survival of the project based on stakeholder incentives.
5. Analysis should consider the courses, magnitude and effects of the risks associated with a project by taking into account the possible range in the values for basic variables and assessing the robustness of the project outcomes with respect to changes in these values.
6. The economic analysis should examine the consistency with the Bank's poverty reduction strategy.
7. The economic evaluation of Bank-financed projects should take into account any domestic or cross-border externalities.

In what concerns the economic evaluation, the key aim is to measure the magnitude of the economic impact resulting from the investment.

The World Bank adopts a CBA for transport projects (The World Bank, 2005). The key issues to be included the CBA are (i) impacts, (ii) modes of transport, and (iii) study area. The World Bank adopts the following formula (The World Bank, 2005):

$$\begin{array}{l}\text{Overall Economic Impact} = \text{Change in transport user benefits} + \text{Change in system operating costs and revenues} + \text{Change in costs of externalities} \\ \qquad - \text{Investment costs}\end{array}$$

The estimation of the *overall economic impact* entails the consideration of the following aspects:

- The scope of the appraisal in terms of mode, study area and range of impacts;
- The calculation of transport user benefits (consumer surplus);
- The calculation of impacts on transport providers and the government (includes producer surplus and investment costs);
- Monetary valuation of time and safety;
- The treatment of environmental impacts and other externalities;
- The mechanics of the process including inputs, project life, discounting, aggregation of benefits and costs, unit of account.

3.3 National level projects and their linkages

The standard economic appraisal technique of the European Commission is the CBA (European Commission, 2014). The EC has been promoting CBA for the appraisal of major infrastructure projects above €50 million. The basic rules of conducting CBAs were included, for the first time ever in the secondary legislation and are binding for all beneficiaries in the 2014–2020 program period. CBA is explicitly required, among other elements, as a basis for decision making on the co-financing of major projects included in operational programs of the European Regional Development Fund and the Cohesion Fund. A major project is defined as a project which comprises of an economically indivisible series of works fulfilling a precise technical function having clearly identified aims and whose total cost taken into account in determining the contribution of the funds exceeds 50 million euro or 75 million euro in the case of a transport project. The approval of the Commission is required at the individual project level (European Court of Auditors, 2018). The standard CBA adopted by the European Commission is structured in seven steps, as follows: (i) Description of the context, (ii) Definition of objectives, (iii) Identification of the project, (iv) Technical feasibility and Environmental sustainability, (v) Financial analysis, (vi) Economic analysis, and (vii) Risk assessment. Apart some minor differences, the CBA techniques adopted by the EIB and the EC[i] are similar.

The time horizon or reference period is a key decision in a CBA, as it affects the appraisal results. The EC proposed the reference periods listed in Table 1.

Key methodological topics specific of freight transport projects at the national level are the freight value of time, road vehicle operating costs. These form key inputs to the calculation of benefits of transport projects as they are the multipliers for the key economic drivers of project feasibility: speed (due to improved road quality, upgrading of roads and reduced congestion) and distance (shorter routes). We discuss these below.

Value of time: reduction in travel times accruing from the transport project will benefit freight traffic in terms of (1) reduced driver (and any other persons necessarily traveling with the load) wage costs per trip; (2) reduced vehicle operating costs per trip; and (3) improved reliability, i.e., timely delivery of transported goods. EIB acknowledges that the value of time is the outcome of a consumer decision process. In many situations, consumers have to trade between time and money. These situations can be described by models. Common models are mode choice models, route choice models or alternative choice models within the same mode and route, but with different travel time and costs. Data used in model estimation can be classified as revealed preference (RP) data (actual choice data) or stated preference (SP) data (choices as stated by shippers in interviews).

The European Commission indicates that the methodology for the estimation of time value for freight should be based on the capital lock-up approach. This approach considers that the value of time related to the movement of goods includes the interest costs on the capital invested in

Table 1 European Commission's reference periods by sector.

Sector	**Reference period (years)**
Railways	30
Roads	25–30
Ports and airports	25

[i] Comparing with the traditional CBA, see Koopmans and Mouter (2020) and Mouter (2021), the EIB and EC CBA techniques exhibit some conceptual differences, such as a clearer assessment of the technical and environmental sustainability.

the goods during the time that the transport takes (important for high-value goods), and a reduction in the value of perishable goods during transit. Additionally, it considers that the production process can disrupted by missing inputs or that customers cannot be supplied due to lack of stock. The valuation of the freight's value of time requires therefore an in-depth analysis of the member state's transport and logistic and supply sectors.

There is a rich literature dedicated to estimating the freight value of time.[j] Table 2 presents a selected list of reference compiled by Feo-Valero et al. (2011). The main evidence is the wide diversity of situations and findings, which raises difficulties in the moment of choosing a value for international projects.

Road vehicle operating costs: a key impact of road projects, after time savings in most developed countries, is the reduction of Vehicle Operating Costs (VOCs). Operating cost relationships for road vehicles are relatively generic and transferable within countries. The main components of VOCs and their relative contributions used by EIB are listed below (Table 3).

These numbers are the subject of national guidelines and their application is typically obligatory, as in the case of passenger transport.

Table 2 Selected value of time for freight transport.

Country	Mode	Geographical domain	Freight value of time (2005, €per hour and tonne)
United States	Road, Rail, Air	National, International	• Regular shipments: 0.012€ per day per dollar of value; • Emergency shipments: 0.49€ per day per dollar of value
France	Road, Rail	National, International	• Shipment in batches: 3.1 • Isolated shipment: 4.83 • Shipment in containers: 3.28 • Shipment in pallets: 9.84 • Shipment origin—warehouse: 4.14 • Shipment origin—factory: 4.83 • Shipment origin—distribution centre: 3.28

[j] Further detail about the value of travel time and travel time reliability can be found in De Jong and Kouwenhoven) of this book.

Table 2 Selected value of time for freight transport.—cont'd

Country	Mode	Geographical domain	Freight value of time (2005, €per hour and tonne)
Italy	Road, Maritime	National, International	• (0.14–1.63) average 0.65
Italy	Road, Maritime	International	• (3.31–7.4) average 3.71
Spain	Road, Maritime	International	• Full-loaded shipments 1.85
Norway	Road	National	• Edible refrigerated goods: (0.41–340.73) with an average of 14.72
Sweden	Road		• Company owns its lorries: 2.45 • Company hires lorries: 0.35 • Short-distance shipment: 5.18 • Long-distance shipment: 0.38
United Kingdom	Road	National	• Own transport: 1.1 • Transport subcontracted: 1.75 • Specialized in complete shipments: 1.56 • Specialized in consolidated shipments: 1.41
Netherlands	Road	National	• Low-value raw materials and semi-processed goods: 2.55 • High-value raw materials and semi-processed goods: 2.81 • Final consumer perishables: 2.35 • Final consumer non-perishables: 2.15
Finland	Road	National	• Willingness to pay, one-hour reduction in transit time: 0.98 • Willingness to accept one-hour increase in transit time: 2.24 • Forestry industry: 0.28 • Metal industry: 2.03 • Electronics industry: 3.22 • Consumer goods: 1.44 • • Technical goods: 0.93
Belgium	Road	International	2.88

Source: Feo-Valero et al., 2011.

Table 3 Components of VOCs and their relative contributions

Component	Percentage contribution (trucks)
Fuel	10–30
Lubricating oil	<2
Spare parts	10–30
Maintenance (labor)	<8
Tyres	5–15
Depreciation	10–40
Crew costs	5–50
Other costs and overheads	5–20

3.4 City level appraisals

Urban logistics is "the means over which freight distribution can take place in urban areas as well as the strategies that can improve its overall efficiency while mitigating externalities such as congestion and emissions. It includes the provision of services contributing to efficiently managing the movements of goods in cities and providing innovative responses to customer demands" (Rodrigue and Dablanc, 2020). Urban logistics is a very complex system on its own. The concentration of three aspects on a relatively small area makes this system very complex:

- the issues generated specifically by freight transport, including congestion, the degradation of infrastructure and local emissions.
- the ecosystem of stakeholders like producers, logistics and freight transport operators, retailers, citizens or public authorities.
- the diversity of logistics sub-networks, in terms of the type of goods (e.g., food vs non-food delivery), location (e.g., office vs home deliveries), nature (e.g., express services).

Most of the urban freight logistic distribution is made by road vehicles (two-wheelers, cars, vans and small trucks). These vehicles compete against private and public transport vehicles for the scarce road transport infrastructure. Add to this, freight vehicles, notably trucks, are slower and occupy more space than cars. The outcome is the worsening of traffic conditions—that is congestion (e.g., a double parked truck creates a bottleneck in the traffic capacity of the road), growing conflicts with other users, notable pedestrians (in case of parking on side walk), increase in fuel consumption, increased unreliability, etc. The impacts of congestion on the efficiency of transport operations are well documented (Figliozzi, 2010). Every year €100 billion, or 1% of the EU GDP, are lost to the European economy as a result of delays and pollution related to urban traffic (ALICE and ERTRAC Urban Mobility WG, 2015). In parallel with congestion, annoyance and unsafety due to loading and unloading operations are another relevant challenge of urban freight logistics operations, with significant impacts on the safety of road users and pedestrians (Fig. 3). Often, parking occurs outside designated parking bays in illegal conditions (e.g., second lane, bus lanes, on the sidewalks or on illegal parking places). Such practices reduce the road or sidewalks capacity, leading to congestion or forcing pedestrians to divert, eventually onto the street. On the other hand, the very movement of goods in between the vehicle and the shops is prone to accidents and conflicts with users. The roots are diverse, but include the lack of suitable parking places (indeed, parking places for freight vehicles are scarce, often located in secondary roads away from shops, and when available can be occupied by private vehicles). Also, many deliveries are done in a very short period of time (<3 min). In these cases, there is a higher propensity to commit illegal actions (for example, park the vehicle in double lane). The time of the illegal act is short and the probability to be caught by public authorities is low.

Degradation of local environment is another relevant impact of urban freight logistics. A recent study concluded that if we compare a city with a fleet including only euro 6 vehicles in 2030, to the same city in 2010 composed by an average EURO 4 fleet, the reduction in emissions from the vehicles, all things being equal, could be of 80% for PM and 90% for NOx (ALICE and ERTRAC Urban Mobility WG, 2015). The impact on quality of life, notably health-related problems cannot be neglected. An additional impact concerns the noise of urban freight logistics operations,

Fig. 3 Unlawful (un)loading of beverages on the sidewalk in Lisbon downtown. *Source: V. Reis.*

this refers not only to the very movement of freight vehicles (including engine), but mainly to the loading and unloading operations (e.g., opening and closing doors, moving carts back and forth, loading and unloading the vehicle). A recurrent challenge relating to urban freight logistics refers to the enforcement of legislation and regulations. Indeed, an adequate enforcement is the key to ensure that law and regulations are complied with.

Another relevant challenge stems directly from the eminently private nature of urban freight logistics, which is the stakeholders' general low interest for cooperation. Policymaking in such a context requires well-designed consultation and participation processes due to the complexity of issues involved and diverse interests of various stakeholders. This allows the full narrative about impacts to be known beforehand, which is necessary to understand critical factors and helps to avoid sub-optimization.

Solutions suggested to support urban freight transport and mitigate its impacts are manifold, and there is an extensive literature that discusses pros and cons of alternative policies (Heitz and Dablanc, 2019; Taniguchi et al., 2016; Ville et al., 2010). Policies that can be implemented at the local level roughly fall into three categories:

- Infrastructure measures, e.g., street lay-out and consolidation centers for public use,
- Traffic management measures, e.g., access regulation and route guidance,
- Pricing measures, e.g., congestion charging or environmental access charges.

Despite the strong involvement of academia and consultants in local policy initiatives, systematic evaluations, and comparisons of evaluation results across cities, are rare (Gonzalez-Feliu, 2018). Many times, evaluations are limited to the single company level and it remains unclear to what extent citizens will benefit of new schemes. Methods followed for the actual assessment exercises will depend on the type of initiative and may involve CBA, life cycle cost analysis, MCA, etc.

Arguably, the first appraisal methods of urban logistics initiatives[k] were discussed in the first international conference for urban logistics and published in the respective proceedings (Mizutani, 1999; Ooishi and Taniguchi, 1999; Takahashi and Hyodo, 1999). The proposed methodologies were essentially simulation and scenario analyses. Since then, several other authors have contributed with either refinements of these methodologies or the proposal of new ones. The initial simulation methodologies focused more on

[k] More info at https://citylogistics.org/ (accessed on the 15th May 2020),

the modeling aspects of urban logistics dynamics. By way of example, Regan and Garrido (2000) used a classical four-step model to estimate freight flows, operating costs and environmental footprint. Meanwhile Gentile and Vigo (2013) argue that the classical four step model is unsuitable for modeling the demand for urban logistics). Another approach was the appraisal of urban initiatives, notably environmental impacts, using available (or producing) data, including logistics (e.g., French Urban Goods Transport surveys), socio-economic (e.g., location of commerce, retail and other business activities, waste management) or demographic data (e.g., household trip surveys). Segalou et al. (2004) proposed an estimate on the environmental impacts of urban logistics based on the transport flows taken from several databases, including the French Urban Goods Transport survey. Recently, with the emergence of e-commerce, other authors conducted surveys and measurement to appraise e-commerce delivery systems. The key indicators (or decision variables) were mainly logistical (e.g., vehicle routing, total distance traveled, number and location of stops) and environmental (e.g., total emissions of greenhouse gases, which could be derived from the previous types of indicators). These approaches were mainly motivated by the analysis and discussion of the results; and not so much by the use of the impacts in decision-making processes.

One of the first systematic and comprehensive CBAs was proposed by van Duin et al. (2008) using a vehicle routing optimization model, the authors estimated the monetary costs in accordance with the CBA of several medium-term development scenarios of urban consolidation centers. Other works using CBA analysis have been published by Holmgren (2018) or Gonzalez-Feliu (2014).

Notwithstanding, the literature on urban freight policy assessment has shown to favor MCAs, for very practical reasons (Gonzalez-Feliu et al., 2013; Huang et al., 2020; Jamshidi et al., 2019; Wątróbski, 2016; Wątróbski et al., 2017):

– No need for specialized training in economics,
– Simple to understand and communicate to stakeholders, including politicians and the public,
– Transparent and stable in evaluation criteria and their weights,
– Possible to record situational preferences of stakeholders at very low costs,
– Easy presentation of the decision problem in simple tables and charts.

An increasingly known method, that acknowledges the diversity of agents and respective strategies and ambitions, is the Multi-Actor Multi-Criteria Analysis (MAMCA), as originally published by Macharis (2000, 2007).

Table 4 Selected authors and criteria.

Authors	Categories and criteria
Morana and Gonzalez-Feliu (2015)	Around 5–10 indicators, chosen from a pool of around 80 indicators
Melo and Costa (2011)	Around 50 indicators, manly economic and operational
Patier and Browne (2010)	Around 65 indicators from 6 categories (economy, social, environmental, equity, feasibility, plausibility)
Patier et al. (2008)	More than 30 indicators from 5 categories: (economic, environmental, societal, ergonomic and regulatory)

Unlike a conventional multicriteria analysis where alternatives are evaluated on several criteria, the MAMCA methodology explicitly includes the points of view of the different stakeholders. Over the years an increasing number of indicators and criteria have been proposed for these evaluations. Table 4 presents a selected list of authors and respective amount and types of criteria.

These growing lists of criteria are symptomatic for the increasing use of appraisal in fast-paced incremental innovation processes, where the steps made are smaller and the potential impact of decisions is therefore lighter. This allows for the necessary attention to the embedding of decisions in local stakeholder circles, with refined and continuous measurements of impacts. These so-called "living labs" form a new governance context for appraisals, which differ vastly from the "big bang" innovation context that city logistics projects and policies have suffered from (Quak et al., 2016).

4. Conclusions and research agenda

Appraisals of projects and policies in the area of freight transport have many common traits with passenger transport projects, but there are also interesting differences. As appraisal practice has mostly depended on passenger transport projects, it is interesting to understand these better with an aim to improve appraisal guidelines and practices. We summarize the policy relevant traits of freight system appraisal below and include some recommendations for research in the discussion.

Generally, in an appraisal process, the narrative about the foreseen impact pathway of a project is a very important starting point for quantitative assessment. The freight transport system can play a major role in these stories, even if projects are not directly or not only intended for freight transport. As the freight side of the study is often neglected, it is worthwhile to try to increase our understanding of all the mechanisms of the system and how these are intertwined with passenger transport processes, and economic activity in general. Freight transport serves market for products and services worldwide, through global supply chains, reaching firms and consumers everywhere. With that, the potential scope and breadth of a freight transport project appraisal is daunting. The users of the freight transport system are companies who supply a service to other companies or to consumers—the chain from infrastructure projects and policies to consumer benefits is many times indirect, and influenced by many different decisions of these actors. Freight transport also has important linkages with passenger transportation through transport motives like shopping, commuting and business. These motives interact at the level of economic activities (through firms and individuals buying, producing and selling goods) and at the level of traffic (through congestion). Guidelines for integrative appraisals are rare. Also, integrative models that link freight and passenger transport processes, as described in this chapter, are lacking in practice and are therefore not applied in policy appraisal. Research can help to map freight and passenger transport interactions, develop consistent system models and support the development of integrative guidelines for appraisal.

Freight transport appraisal has its own specific analysis problems, which deserve continuous research. These include the propagation of costs and benefits through supply chains (carriers transferring cost increases to their clients, shippers absorbing cost increases through logistic trade-offs), the complex question of additionality of quantified impacts (ensuring in the appraisal that impacts are collectively exhaustive and mutually exclusive) and the wide reach of indirect effects (supply chains quickly lead to effects of an international or even global nature, to a point where these effects become intractable for most studies). These issues all require research, to allow us to conceptualize and quantify impacts in a consistent way, with broad agreement from stakeholders.

There is a major imbalance in processes and methods of appraisal between countries around the world and between geographical layers (local, national, international). This is a problem when projects are multi-jurisdictional, when there is no clear joint decision power and where some degree of consensus or consistency needs to be reached. Projects with overlapping or connected jurisdictions can be many: a city project may desire co-financing from the national level, or countries may want to invest together in shared infrastructure. The dominant practice at the national level and above is cost-benefit analysis (CBA), with methods and techniques being slightly less rigorously prescribed at the higher spatial level. Internationally, the distribution of benefits does not seem to play a role in the appraisals and decisions about major infrastructure projects. At the urban level, appraisals have mostly relied on multi-criteria analysis (MCA), hindering the connection with national level cost-benefit analysis. How to move from this system of geographically inconsistent and disconnected appraisal approaches is unclear. Research could inform policy makers about new directions for appraisal to repair this caveat.

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