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Economic, social and environmental impact assessment for off-site construction logistics: the data availability issue

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Abstract. Introduction. The ongoing urbanization trend makes local governments densify their built environment, hence stimulating construction and renovation works in urban areas. Construction intrinsically strongly relies on logistics activities, which in turn are the source of environmental nuisances. The latter are referred to as external costs when they are not borne by the polluter himself, such as greenhouse gas emissions, air pollution, congestion, etc. Accurate external cost calculations require accurate data to consider significant calculation-variables. However, current calculations are often based on the number of vehicles used and on transported volume rather than vehicle- or tonne-kilometres, hence not adequate to conduct external cost calculations. **Methods.** The MIMIC-project[1] aims to reduce the impact of construction logistics. Therefore, an integrated impact assessment framework will be developed, assessing the economic and environmental influence of different off-site construction logistics solutions. The necessary data to conduct such an impact assessment are however not always available, complicating calculations. This paper highlights the current gap in accurate data on urban construction logistics flows, the considerable uncertainty about existing figures on construction transport and their methodology, and presents the data availability issue in the development of such a framework, using empirical research. **Results.** Logistics flows data are typically scattered amongst different actors and various in format. Harmonizing different data categories and sources to feed the framework with relevant logistics variables, this paper presents what is possible to calculate using available data in 4 pilot cases in Belgium, Sweden, Norway and Austria. The various data sources highlight the complexity to develop a framework flexible enough to cope with specific local constraints, whilst generic enough to allow comparability across the European cases, and ultimately across construction logistics globally. Furthermore, a shift is needed towards other data collection methods (GPS, digital waybills etc.). **Conclusions.** This paper presents the data availability issue in the development of an impact assessment framework for construction logistics, harmonizing different data sources in order to conduct external cost calculations for construction transport.
Keywords. Construction logistics, data availability, impact assessment framework, harmonization.

1. Introduction

Since 2007, the urban population surpassed the rural population globally. Figures from 2014 show that 75% of the European population was living in urban areas, a share which is expected to rise even further [1,2]. Given this ongoing urbanization trend, local governments focus on densifying their built environment, hence stimulating construction and renovation works in urban areas [1], leading to the construction of new infrastructure or complexes, and the renovation or refurbishment of older ones. Being a natural way for a city to evolve [3], construction often leads to more attractive and economically viable cities in the long run.

Urban construction intrinsically strongly relies on logistics activities [4], and as much as 60–80% of the gross work involves materials and services purchased from suppliers and subcontractors [5]. Given the products (i.e. buildings) are physically big and immobile and are produced at the site of use [6], a

[1] The MIMIC project receives funding from the European Union's Horizon 2020 research and innovation program and is part of the research programme JPI Urban Europe.

great number of transports are needed to ensure on-site deliveries of the right resources at the right time [7,8]. However, the logistics activities related to construction are, if not handled appropriately, the source of significant environmental nuisances [8,9]. The latter are referred to as external costs when they are not borne by the polluter himself [10,11]. Some of the main external cost categories of transport include air pollution, greenhouse gas emissions, noise pollution, congestion, accidents and infrastructure costs [9,12,13,14,15].

To understand the impact of construction logistics we need data. However, there is a gap in accurate data on urban construction logistics flows. Though, estimates from European countries assume about 20-35% of all urban freight traffic would be linked to the sector [16,17,18]. In order to conduct accurate external cost calculations, accurate data is needed to consider significant calculation-variables which are typically scarce and scattered amongst different actors across the construction chain.

This paper highlights (1) the current gap in accurate data on urban construction logistics flows, (2) the considerable uncertainty about existing figures on construction transport and their methodology and (3) presents the data availability issue in the development of an integrated impact assessment framework for construction logistics, harmonizing different data categories and sources to feed the framework with relevant logistics data. The development of this framework is part of the MIMIC project, focusing on the social, economic and environmental sustainability problems that arise from logistics activities to, from, around and on urban construction sites. Hence, it strongly relates to goals 9, 11, 12 and 13[2] of the global sustainability goals [19]. More specifically, the development of the integrated impact assessment framework aims to move closer towards a sustainable built environment, first within the project with multiple demonstration cases across Europe, and ultimately across the sector globally.

2. Literature review

As estimated by the European Commission, the size of external costs of transport in the EU totals approximately 1,000 billion euro per year, or roughly 7% of the EU28's GDP [20]. Construction has a large share of total freight traffic in urban areas. In terms of weight, construction would generate up to 30% of the tonnage transported within cities [17]. However, to perform accurate external cost calculations, there is a need for accurate data to enable the consideration of significant calculation-variables, like vehicle-type, road type, traffic situation, number of receptors, etc.

2.1 The reported share of construction logistics in urban freight traffic and external cost estimates for off-site construction logistics

To perform accurate external cost calculations, there is a need for accurate data on construction logistics. Four transport performance indicators can be distinguished, namely (1) number of vehicles used, (2) transported volume, (3) vehicle-kilometres and (4) tonne-kilometres, for which the last 2 are the most relevant for external cost calculations. Next, we discuss the methodologies used to estimate the share of construction logistics, including their advantages and disadvantages. Several examples will illustrate their use.

Traffic counts are most often used to estimate transport logistics and construction logistics specifically [16,18]. In Brussels, they enabled the calculation of the number of freight vehicles in the total share of traffic. Estimations based on visual identification indicate construction transport represents 17,5% (in 2008) and 20% (in 2016) of total traffic in the Brussels Capital Region (BCR) [16]. In their methodological context, the analyses were mainly carried out with the help of pneumatic meters placed on the main road axes. The vehicle types were then differentiated based on standard axle spacing. This leads to inaccuracies such as buses and coaches to be counted as trucks, or small vans to be considered as cars. Where automatic counts were not possible (e.g. motorways were the width of the lanes are too wide to install pneumatic readers), video techniques have been used to identify the observations. For the latter, no cars were included in the calculations. In turn, the differentiation between freight transport sectors, such as construction, has been approximated using visual recognition of vehicles on the main

[2] SDG 9: Industry, innovation and infrastructure; SDG 11: Sustainable cities and communities; SDG 12: Responsible production and consumption; SDG 13: Climate action.

road axes. It is important to note that there is thus still great uncertainty about the actual vehicle use (going beyond the vehicle identification, such as cargo type, products transported, loading rate, 3rd party logistics etc.) [21]. The advantage of traffic counts is the limited number of man-hours needed to get data for a relatively long time period. Also, they give an indication on the traffic circumstances on the considered spots. The disadvantages are, besides the already mentioned inaccuracy, the limited geographical scope, as only specific locations can be considered. Traffic counts do not give information on origin and destination – and related vehicle-kilometres. Moreover, they don't give information on loading rate. Finally, they don't consider the sector. To estimate the share of construction logistics, additional surveys are needed, and most often used. These can consist of visual counting via cameras or on the streets or construction sites. Their results suggest that the share of construction logistics is about 20% of all urban freight traffic.

Surveys were already mentioned. Many studies [i.a.18,22,23] use questionnaires as survey method to estimate the transport flows of the construction sector. The advantage of this method is that it enables the researcher to ask the data he/she needs, in this case to get origin-destination data and related transported volumes. Vehicle-kilometres and tonne-kilometres can consequently be derived. The disadvantage of this method is that it is very time-consuming and that the results are highly depending on the willingness to participate and to gather the data. Logistics is not the principal activity of the construction companies; therefore, data gathering is a time-consuming and sometimes impossible task for them.

Governments – cities in particular – start to address logistics as a relevant topic. This leads to policies regarding logistics activities and related methods to enforce those policies. Camera technologies (e.g. ANPR) and GPS technologies (e.g. on-board units) are currently used in Belgium to enforce regional and local policies regarding freight transport. These technologies offer opportunities to estimate transport performance, impact of policies and shares of different economic sectors. Where cameras are confronted with the same geographical limitations as traffic counts, they can give a rough estimation of the sector for which transport vehicles are used. GPS trackers on their side, give more relevant information, as they include vehicle type, traffic conditions and routing (vehicle-kilometres). The disadvantage is that they don't consider the sector, neither the loading rate of the vehicle.

It is also possible to collect digital data about transports to and from the project. This data is e.g. available as part of construction logistics setups (CLSs) such as checkpoints [6,24] or construction consolidation centres (CCCs) [4,25,26]. These setups gather data with the help of either or both booking calendars and sensors at the gates. Usually the demand to gather this data comes from municipalities and developers in the need for maintaining a accessibility and mobility [27].

Further data sources can also serve as validation for the above-mentioned traffic flow and freight transport data. The Construction Scope Statement and the Bill of Quantities in which, i.a., the total material needs associated with their volume, weight and price are itemized, can further serve to crossmatch the transport trips to the construction planning. These construction planning data can further feed and validate freight flows, and can serve as an indication of the efficiency of transported volume (loading rate). This information could also be derived from invoices or consignment notes. While the latter documents are still heavily used in analogue formats today, technologic advances will stimulate the use of digital waybills (e-CMR), hence facilitating data gathering and analyses in the future.

In Brussels, approximately 120,000 construction sites in the regional public space are identified annually [28]. The share of construction logistics flows in the BCR is, as highlighted above, currently based on traffic counts. These figures need to be solidified in future studies.

In London, the construction industry is said to represent 35% of daytime Heavy Goods Vehicle (HGV) traffic and 38% of am peak traffic, equaling some 836,859 transport-kilometers a day in the City. This significant amount of freight movements is reported to cost the City of London £779,908,000 annually [18,23]. To map the transport flows needed to compute these figures (and the inefficiencies in the construction logistics planning), data was mainly sourced from Delivery Management Systems (DMS), manual field data collection and survey work, thus heavily relying on manual data collection and stakeholder interviews. While these figures give a broad overview of the total damage costs generated by the sector in London, educated assumptions have been used to calculate external costs of transport thereby lacking to consider crucial local variables (like receptor densities and traffic situations) intertwining with the internal economic costs of bore by the contractors. It is thus worth pointing out these figures also and mainly encompass internal operating costs. For **CO_2-equivalent calculations,** a fix basis of 2.64 kg of CO2e per litre of diesel burnt and damage cost of £31 per tonne of CO_2-e was taken into account (based on simple calculations provided by the Department of Transport in 2010). While there is indeed a one-to-one relationship between number of liters burnt and CO_2 emissions, the monetary value of £31 is very low compared to recent literature suggesting a central value for carbon price of €80-100/tonne CO_2-equivalent (€$_{2016}$) [9,29,30,31]. Idling time was assumed to represent 50% of the total amount of delay time, for which 2l (diesel)/hour/truck and 0.63l/hour/van was taken into consideration. **Local emissions** (air pollution) were computed per KWh based on emissions standards, for which 11.92 KWh/l (diesel) was used in conversion for lorries. Light Duty Vehicles (LDV) and vans calculations were based on distance driven (6l/100km in conversion). Analogically to climate change costs, air pollution was measured against a fixed economic value of £80,658 per tonne of NO_x and £178,447 per tonne of PM. **Infrastructure damage** was calculated using the gross weight of the vehicle and the number of axles (legal limit). The total annual cost of infrastructure damage was then calculated evaluated on the number of wasted kilometres, based on a damage cost of £0.001/km and 4 deliveries/day travelling an extra 16.27km. **Congestion** costs were also taken into account, but only the economic (internal) costs of delay for the contractor are presented. In terms of **accident costs**, construction vehicles would account for 79% of the cyclist fatalities involving a heavy goods vehicle in London [18,32,33] (calculated based on 16 cyclist fatalities in 2011 and sample analysis of collision and exposure files). Note that **noise** nuisance is not considered.

In the Netherlands, a report from TNO states that 30 to 40% of the freight traffic (in number of vehicles) in Amsterdam would be related to construction projects [34]. Furthermore, 3 to 5 out of 10 lorries would have a construction site as end destination [35]. The department for transport and logistics in The Netherlands also presents a 30% share of transported tonnages in a city, in line with the percentage presented by Dablanc in 2009 [17]. Other figures estimate construction to be responsible for 15 to 20% of the number of trucks, and 30 to 40% of vans in cities [8,36,37,38]. In the Netherlands, 27% of all **greenhouse gas emissions** in 2015 are attributable to construction logistics[3] [39]. Converted, the sector in the same year was responsible for almost 1Mtonne of emitted greenhouse gas (GHG) emissions in the Netherlands. Methodologically, CO_2 emissions (emission factors) generated by urban logistics in this study have been derived by combining a top-down analysis using statistical data from Eurostat and CBS, along with a bottom-up analysis using data from supply profile studies in the construction sector [39,40]. Important to note is the significant uncertainty in the share of vehicles in the sector. While one could assume construction mainly relies on heavy duty vehicles (HDVs) to transport significant volumes, the impact of the sector in terms of CO_2 emissions strongly originates from vans [39]. In terms of number of vehicle-kilometers (vkm), it is estimated 53% of vans are used for construction and services activities in the Netherlands [37]. In terms of **accident costs**, in the city centre of Amsterdam in 2017, 80% of traffic accidents were related to construction traffic [36].

In the city of Oslo, 61% of greenhouse gas emissions would have their origins from transport, including both people and freight [41]. Within this segment, 55% come from construction machinery, heavy duty vehicles, and vans [41]. Regarding mobile combustion emissions[4], construction machinery is estimated to be the largest source. However, there is still uncertainty on the rough data (sources) used and the cause of the emissions [42].

In Sweden, in terms of transported weight, construction traffic would represent 20% in total freight traffic [43]. However, figures are presumably based on assumptions, as no transparent methodology is shown on how the approximation was made.

2.2 Robustness of current construction logistics data and impact assessments

Limited available and robust effectiveness studies were found regarding data on urban construction logistics flows, in part due to lack of data and different evaluation methods and scopes. The scarcity of

[3] Encompassing infrastructure, buildings for large construction companies, SME/Selfemployed and building materials supply.
[4] Encompassing on site machinery and diesel driven mobile heating sources (during winter)

construction logistics data and different datasets and output values in different regions might lead to ambiguous results. The difficulty in estimating the size of the construction logistics sector, in turn, also leads to large inaccuracies and variations when calculating external costs of construction transport and their relative proportion across the urban freight transport (UFT) sector. Overall, little is known about the actual vehicle-kilometers (vkm) linked to the significant number of vehicles in the sector, and the available info so far seems to be consolidated using educated guesses. In order to assess the share of construction logistics in urban traffic and its societal and environmental impact, the most relevant performance indicators are tonne-kilometres and vehicle-kilometers. However, the current calculations of the sector's share are most often based on the number of vehicles used and on transported volume, hence not adequate to conduct external cost calculations.

3. Development of an integrated economic, social and economic impact assessment for construction logistics and methodology

3.1 Scope and methodology

The overall MIMIC project goal is to reduce the negative impact of construction sites by improving the governance of construction logistics. Based on current knowledge of sustainability impacts of logistics operations, construction management and existing calculation tools, a framework will be set up to monitor and quantify the off-site economic, social and environmental impact of construction logistics scenarios including major externalities compared to 'business-as-usual'. The External Cost Calculation [44] module, based on the most up-to-date methods and metrics, will be used for the assessment of impacts of construction logistics flows, including climate change, air pollution, congestion, accident costs and traffic safety, noise pollution, transport infrastructure damage, and others, thereby taking into account the relevant variables such as receptor density, time of day, traffic flow, network type and specific vehicles and equipment used in off-site construction logistics.

3.2 Input data for the construction logistics impact assessment framework

The table below presents the major data categories needed to calculate the externalities for off-site construction logistics.

Data category	Data variables	Examples
Origin-Destination Matrix	Total transport flows (vkm/tkm) given origin and destination points (minimal on municipality level)[R]	OD points; geolocations; distance travvelled (vkm) etc.
	Road type[A]	Motorway, local road, etc.
	Environment[A]	Urban, suburban, rural, etc.
Time of day	Hour of the day (differentiation day/night)[A]	Time stamps
Traffic	Loss of time and traffic situation (thin/dense)[A]	Free-flow, heavy traffic, saturated, stop & go
Vehicle type	Transport mode[R]	Barge CETM class 1; van type, HDV type; cargobike; etc.
	Vehicle capacity (size)[R]	14t-20t; 350t (CEMT II); 420m freight train ; etc.
	Vehicle propulsion type[R]	Diesel, electric, LNG ; etc.
	Vehicle consumption[R]	EURO-norm
	Vehicle speed[A]	Trip average speed
	Cargo type[A]	Pallets, bulk, etc.
	Loading rate[A]	Volume (tonne), %

[R] *Minimum data requirement.*
[A] *If no data is available, these could be based on solid assumptions or derived through geocoding or other calculations.*

Table 1. Data requirements to conduct an economic and environmental impact assessment for off-site construction logistics (based on VUB-MOBI's previous transport external cost calculations)

As highlighted in Table 1, there are a few minimum data requirements such as Origin-Destinations (either all off-site transport flows or extrapolated from a relevant sample) encompassing vehicle-kilometres (vkm), next to vehicle/truck type and propulsion type (marked with [R]). Other types of data (such as road type, loading rate etc.) can serve to further enrich and refine the analyses (marked with [A]).

3.3 The data availability issue

The developed impact assessment framework for construction logistics will integrate both the economic and environmental influence of different logistics solutions. Therefore, different national demonstration cases in Belgium, Norway, Sweden and Austria will be analyzed. The necessary data to conduct an impact assessment for off-site construction logistics are however not always available, hence complicating calculations. Multiple factors contribute to the complexity of this framework: (1) the large gap in accurate and available data on urban construction logistics flows; (2) the source of the available logistics data that is typically scattered amongst different actors within the construction chain (e.g. contractor, logistics provider, etc.); (3) The nature of the (unstandardized) data formats, typically distilled from various (and often analogue) sources such as from On-Board Unit data [14], invoice data [45], traffic counts, Construction Consolidation Centres [46,47,48,49], etc. These factors highlight the complexity to develop a framework flexible enough to cope with specific local constraints, whilst generic enough to allow comparability across the national demonstrations, and ultimately across the construction logistics sector. A first step in the development of the framework is therefore to harmonize the different datasets following the data categories listed in Table 1 after collecting relevant off-site transport variables in the different demonstration cases across Europe, as to create a robust framework using available data.

4. Empirical research

This section will focus on (1) identifying which data sources are available in the pilot cases and (2) harmonizing these collected data with what is needed to develop an impact assessment framework.

4.1 Available datasets and data categories for off-site construction logistics flows

Belgium

A first demonstration case is under development in Belgium, where the application of the sustainability impact assessment framework will be tested on the 17.600m² CityCampus project, in collaboration with Brussels Mobility, CityDev (Brussels Regional Development Agency) and main building contractor Van Roey Vastgoed. The data collection on construction logistics-related transport movements will be gathered from On-Board Unit ('OBU') data. The On-Board Units, GPS-based trackers, were introduced in 2016, as to implement a kilometre charge for the use of motorways and certain regional roads in Belgium [50,51], and is mandatory for each road vehicle driving in or through Belgium with a gross vehicle weight of over 3.5t or for vehicles of class N1/BC[5,6]. Because the road price is differentiated based on the distance covered and how environmentally friendly the vehicle is, data collection includes specific vehicle characteristics. The OBU data are a strong dataset for trucks above 3,5t, in order to retrieve the vehicle's position (geometry) through a unique identifier, the vehicle type (transport mode and capacity), the EURO norm (consumption), the time of day (data time stamps per 30 seconds interval) and the velocity of the vehicle. From this dataset, further information can be derived. An algorithm has been developed as to map the vehicle's trajectory (OD-matrix), hence very accurately deriving the number of travelled vehicle-kilometres (vkm) and the duration and speed of the trip. Further enriching the analyses, the network, environment and road types can be derived through batch geocoding, hence converting available parameters (such as manufacturers addresses) into geographic coordinates (latitude/longitude). The response can then be linked to the hierarchical classification of roads on the network by means of geographical information systems (GIS).

Additional data related to construction logistics will be collected for road vehicles below 3,5t, inland waterway (and rail) transport modes (which are not covered by OBU data), as well as their vehicle type and class. This can be achieved by means of digital solutions, such as the implementation of a

[5] The kilometre charging includes all roads in the Brussels Metropolitan Region.
[6] Excluded from this kilometre charge are machine-vehicles (such as cranes, bulldozers, and lifts) and other types of vehicles such as test drive license plated vehicles, old timers, etc.

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construction camera, monitoring the site and its incoming and outcoming logistics activities. The number of vans can then be cross-matched with the Bill of Quantities and the construction planning, while the origin of the vans, barges or trains could be derived from invoice data or cloud logistics solutions. Further validation of information on trip origins and destinations could also be obtained from hauliers in the project. Some information can also be further cross-matched and validated with the construction planning and delivery of building materials on-site. Data on truck loading rates, volumes and receptor densities are not available at this moment, but will be incorporated if accessible. Otherwise, assumptions will be used. For example, traffic situation and loss of time estimations could be based on hourly average traffic information on a fine-grained geographical level.

Sweden

In order to map relevant transportation flows, use cases in Sweden will render datasets on: (1) project data (BTA, project size (SEK), time plans, type of project and location); (2) the number of transports arriving at and leaving from the construction site (with time stamps) including the type of vehicle and its propulsion type, the transported product type and potential damages, fill rates ((un)loadings per truck in kg, ton, pallets, containers etc.), turn-around time, the vehicle's routing, deliveries in accordance to the planning etc.; (3) distribution between vehicles in relation to the total number of transports; (4) potential incidents with third parties; and others. Direct relevant logistics data will thus be obtained on the vehicle type arriving at the site, the vehicle's propulsion type, its loading rate, the transported product type, and the time of day. Trip origins and destinations as well as the transported volume, value and number of packages could also be obtained from certain hauliers, hence linking these data further to the construction planning. In turn, the preferential trajectory to site, the environment and road types can be derived through geocoding and by means of GIS. The vehicle capacity (size) could be derived and approximated using directly available parameters such as fill rates and (un)loadings per truck. Data on traffic situation, vehicle speed, receptor densities and consumption will not be available. However, the vehicle's consumption (given the vehicle's propulsion type) could be based on sound assumptions, for example using national, regional or local statistics and averages.

Norway

The demonstration case in Oslo will provide direct off-site transport datasets on the number of trips (defined as a transport flows to or from a construction site or reverse flows to e.g. a landfill), the origin and destination points per trip, the date of the trip, the number of traveled kilometres, the vehicle type and capacity, the vehicle's propulsion type and consumption (EURO), the type of goods being transported (manufacturer and item) and the goods' weight (gross kg). From these data points, one can derive additional variables such as the road type and the environment (through geocoding and GIS). The vehicle's theoretical loading rate could also be derived from source data, bar the vehicle is not on a milk-run trajectory. The available off-site logistics data only has a temporal resolution of one day, hence being too low to accurately derive the vehicle's average speed from origin to destination or the loss of time in traffic. However, the average velocity of the vehicle, along with the preferential transport trajectory could be derived using geocoding and GIS. No time stamps or traffic situation are available.

Austria

In Vienna, the focus will be on the impact of construction logistics on the city's mobility. To this end, mobile phone-based movement data will be investigated to monitor the impact of urban construction works on city traffic. Direct results from simulations using Mobile Service Provider (MSP) data will render the density of the traffic, while the most probable mobility mode (walking, public transport, car, etc.) and most probable trajectory can be derived through the development of algorithms. Direct data will thus render information on the traffic situation, which can then be overlaid on off-site logistics data. These MSP data thus form an indirect link with the framework and not a direct data source for construction logistics specifically.

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Overview

Table 2 builds further on Table 1, and presents a summary of the above-mentioned findings, harmonizing the available off-site logistics data categories in the four demonstration countries (Belgium, Sweden, Norway and Austria), with the data needs in order to develop the economic, social and environmental impact assessment framework for construction logistics.

Data category	Data variables	Belgium	Sweden	Norway	Austria
Origin-Destination Matrix	Total transport flows (vkm/tkm) given origin and destination points[R]	Y[2]	Y[2]	Y[1]	N/A
	Road type[A]	Y[2]	Y[2]	Y[2]	N/A
	Environment[A]	Y[2]	Y[2]	Y[2]	N/A
Time of day	Hour of the day (differentiation day/night)[A]	Y[1]	Y[1]	N	N/A
Traffic	Loss of time and traffic situation (thin/dense)[A]	N[3]	N	N	Y[1]
Vehicle type	Transport mode[R]	Y[1]	Y[1]	Y[1]	N/A
	Vehicle capacity (size)[R]	Y[1,2]	Y[2]	Y[1]	N/A
	Vehicle propulsion type[R]	N[3]	Y[1]	Y[1]	N/A
	Vehicle consumption[R]	Y[1]	N[3]	Y[1]	N/A
	Vehicle speed[A]	Y[1,2]	N	N[3]	N/A
	Cargo type[A]	N	Y[1]	Y[1]	N/A
	Loading rate[A]	N	Y[1,2]	Y[2]	N/A

[R] Minimum data requirement
[A] If no data is available, these could be based on solid assumptions or derived through geocoding or other calculations
Y: available
N: unavailable
N/A: use case not applicable for off-site construction logistics data gathering
[1] Information directly available from dataset
[2] Information indirectly available from dataset or through other calculations (e.g. OD matrix through algorithm combining GPS points, velocity through time stamps, geocoding, most probable route algorithm, invoice analysis etc.)
[3] Sound assumptions possible.

Table 2 The available data categories in the respective project countries, in relation to the data needs in order to develop the economic, social and environmental impact assessment framework for construction logistics.

4.2 Synergies between Transport, Production and Construction sectors

It is also worth pointing out this framework will be built with the knowledge and expertise of a multidisciplinary consortium, focusing on 3 main pillars in construction logistics: Transport (off-site logistics and thus the focus of this paper), alongside Production (focusing on the construction planning linking together on-site and off-site logistics) and Construction (on-site building and logistics). The synergies between these different points of view thus offer the possibility to assess the impact of construction transport on the economy, society and environment.

5. Conclusions

Despite construction allows to foster more attractive, sustainable and economically viable cities in the long run, the construction logistics activities are, if not handled appropriately, the source of significant environmental nuisances during the site duration. As part of the MIMIC project, a systematic framework will be set up to monitor and quantify the off-site economic, social and environmental impact of construction logistics scenarios including major externalities such as climate change, air pollution, congestion, accident costs and traffic safety, noise pollution and transport infrastructure damage, compared to 'business-as-usual'. The framework will first be tested on 4 pilot demonstration cases in Belgium, Sweden, Norway and Austria. The necessary data to conduct an impact assessment for off-site construction logistics are however not always available, hence complicating calculations. Multiple factors contribute to the complexity of feeding this framework: (1) the large gap in accurate and available data on urban construction logistics flows; (2) the source of the available logistics data that is typically scattered amongst different actors within the construction chain and (3) The nature of the (unstandardized) data formats, typically distilled from various sources within the sector.

In order to conduct accurate external cost calculations, accurate data is needed to consider significant calculation-variables, such as vehicle-type, road type, traffic situation, number of receptors, etc. In turn, four transport performance indicators can be distinguished, namely (1) number of vehicles used, (2) transported volume, (3) vehicle-kilometres and (4) tonne-kilometres. In order to assess the share of construction logistics in urban traffic and its societal and environmental impact, the most relevant performance indicators are tonne-kilometres and vehicle-kilometers. Currently, very little is known about the actual vehicle-kilometers (vkm) linked to the significant number vehicles in the sector, and the available info so far seems to be consolidated using educated guesses. Hence, current calculations are most often based on the number of vehicles used and on transported volume, hence not adequate to conduct external cost calculations.

Collecting the available data categories, this paper presents the data availability issue in the development of an integrated impact assessment framework. Harmonizing different data categories and sources to feed the framework with relevant logistics data, it presents what is possible to calculate given the available data in 4 pilot demonstration cases across Europe. As depicted, some minimum requirements need to be met. These directly available data can be the source of computations to derive other calculation-variables accurately to enrich the external cost assessment. However, the various data sources also highlight the complexity to develop a framework flexible enough to cope with specific local constraints, whilst generic enough to allow comparability across the demonstration cases, and ultimately across the construction logistics sector. Furthermore, a shift is needed towards other data collection methods (such as GPS, digital waybills etc.).

The development of the integrated impact assessment framework aims to move closer towards a sustainable built environment, ultimately across the sector globally. Hence, it strongly relates to goals 9,11, 12 and 13 of the global sustainability goals [19], as to reduce the volume and impact of construction road freight, stimulate more sustainable means of transportation and overall mitigate the external costs of transport.

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