

SUSTAINABLE FREIGHT DELIVERIES IN THE PEDESTRIAN ZONE: FACILITATING THE NECESSITY

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► State of the art paper

FR

Bien que l'extension de la zone piétonne à Bruxelles ne vise pas le « Urban Freight Transport » (UFT, transport urbain de marchandises), l'interdiction (partielle) des véhicules motorisés sur la zone modifie la manière dont les livraisons y sont effectuées. Ce papier explore les effets de la piétonisation sur l'UFT dans d'autres villes pour mettre en évidence des effets qui devraient être surveillés à Bruxelles. Les recherches spécialisées sur Bruxelles à cet égard sont peu nombreuses. Par conséquent, cette analyse a pu étayer l'analyse en nous appuyant sur des études internationales qui abordent souvent les questions sur la régulation de l'accessibilité aux véhicules motorisés (fenêtres temporelles). Il en ressort deux types d'impacts: des effets économiques pour les acteurs commerciaux et des changements des systèmes de transport. Sur base de cadres d'évaluation européens du UFT, nous recommandons de surveiller une série d'effets sociétaux et environnementaux tels que les émissions, la sécurité routière, etc. Nous suggérons également de diversifier les méthodes de collecte de données : en surveillant les transporteurs et les receveurs de manière régulière et structurée, et en utilisant des méthodes intelligentes de collecte de données tant que possible.

NL

Door het verbod op gemotoriseerd verkeer in de recent uitgebreide voetgangerszone in Brussel moeten logistieke dienstverleners hun gewoontes aanpassen als ze er goederen leveren. In deze paper geven we een overzicht van de gekende effecten van andere voetgangerszones op stedelijk goederenvervoer om een goed zicht te krijgen op welke effecten best gemonitord kunnen worden in Brussel. De link tussen voetgangerszones en stedelijk goederenvervoer wordt echter weinig gemaakt in bestaand onderzoek. Daarom werd het overzicht uitgebreid met de effecten van maatregelen die veel gelijkenissen vertonen met het invoeren van een voetgangerszone: tijdsvensters en verschillende voertuigbeperkingen. Er blijken twee soorten effecten te zijn: economische effecten voor de commerciële stakeholders die de vraag naar stedelijk goederenvervoer gaan beïnvloeden en veranderingen in het eigenlijke transportsysteem waardoor de stakeholders hun gedrag moeten aanpassen. Omdat het bestaand onderzoek zo beperkt is, stellen we voor het monitoringsysteem voor Brussel te enten op de evaluatiekaders van bestaande Europese onderzoeksprojecten rond stedelijk goederenvervoer en een aantal maatschappelijke en milieueffecten continu op te volgen. We stellen ook voor om op verschillende manieren gegevens te verzamelen: logistieke dienstverleners en ontvangers van goederen structureel bevragen en zoveel mogelijk data gebruiken die nu al automatisch verzameld worden.

EN

Although the extension of the pedestrian zone in Brussels does not target urban freight transport (UFT), the (partial) ban on motorized vehicles changes how deliveries are carried out. This working paper explores the effects of pedestrianisation on UFT in other cities to validate which effects we should monitor in Brussels. Existing research is limited but since pedestrianisation is closely related to time windows and vehicle access restrictions, we used those fields of research for our review. There are two types of impact: economic effects for commercial stakeholders and changes in the transportation system. Based on existing European evaluation frameworks for urban freight transport, we suggest monitoring a range of societal and environmental effects such as emissions, traffic safety, etc. We also suggest to diversify data collection methods: surveying transport operators and receivers on a regular and structured basis and using smart data collection methods whenever possible.

Introduction

Urban freight transport (UFT) concerns transport of goods within, into, within or out of urban areas [Verlinde, 2015]. UFT is heterogeneous and includes very diverse freight flows such as large volumes of consumer goods towards retailers, e-commerce deliveries to individual households, construction, waste logistics, etc. [Dablanc and Rodrigue, 2014]. It includes (1) all types and sizes of goods vehicles and other motorized vehicles for collecting and delivering goods in urban areas, (2) all types of goods vehicle movements to and from urban premises including goods transfers, collections and deliveries, and (3) service vehicle trips and other trips for commercial purposes [Allen *et al.*, 2000].

‘In Brussels, more than half of the freight vehicles are vans’

Most freight transport in Europe is done by road: 71.6% of freight transport is road transport, 29.4% is carried out by rail, inland waterways or pipelines [European Commission, 2014]. Similar European data on modal split in cities are not available. We can expect, though, that road transport is even more dominant in an urban context since rail, inland waterways and pipelines are mainly suited for long-distance transport [Marinov *et al.*, 2013].

Conventionally fuelled light goods vehicles (vans and cars) are the dominant goods vehicle type in cities. Based on a review of 30 urban freight surveys in the UK, Cherrett *et al.* [2012] show that, on average, light goods vehicles are used for 41% of UFT, followed by rigid trucks (38%) and articulated trucks (17%). Lebeau and Macharis [2014] show that in Brussels more than half of the freight vehicles are vans. In Utrecht and Rotterdam (the Netherlands), vans are responsible for 33% and 40% of UFT respectively [Schoemaker *et al.*, 2006]. The same study, however, found that heavy goods vehicles are the dominant mode in Amsterdam (41%) [Schoemaker *et al.*, 2006]. The continuous decrease of the average size of transported consignments, the increasing frequency by which suppliers and transport operators deliver urban stores and other business and the recent growth of e-commerce and vehicle restrictions explains the current high use of small goods vehicles [Ruesch *et al.*, 2016]. The vast majority of urban goods vehicles in Europe use conventional fuel technologies such as diesel [Schoemaker *et al.*, 2006]; the use of electric freight vehicles occurs, but mostly in small-scale pilots [Lebeau, 2016].

This paper explores how the introduction of a pedestrian zone influences UFT within and in the close vicinity of that area. Within cities, particularly in city-centres, pedestrian-only streets or pedestrianisation is a frequently used measure

[Ballantyne *et al.*, 2013]. According to Hass-Klau [1993: 21] a pedestrian zone is “*The removal of traffic from existing city streets. This is usually accompanied by suitable treatment in terms of paving, street furniture and other design details. Those cases in which specific categories of vehicle (e.g. public transport, emergency services and delivery vans) are allowed controlled access are included.*” A common goal of pedestrianising is to create a more attractive environment for residents, shoppers and tourists by improving mobility for cleaner transport modes, particularly pedestrians and cyclists [Soni and Soni, 2016]. A second, related goal, is improving local environmental conditions [Chiquetto, 1997]. Because pedestrianisation often takes place in shopping environments, another intention is to give a boost to the local business environment by making it more attractive for shoppers [Iranmanesh, 2008; Whitehead *et al.*, 2006]. Some case studies observed a change in traffic flows in surrounding streets, improved air quality, a decrease in noise, a change in turnover of local businesses and a rise in property prices [Chiquetto, 1997; Iranmanesh, 2008; Kumar and Ross, 2006; Soni and Soni, 2016]. The effect of pedestrianising an urban area depends on the type of pedestrianisation. Soni and Soni [2016] distinct between three types of pedestrianisation in terms of the regulation of motorized accessibility:

- Full-time pedestrianisation with absolute priority for pedestrians and with possible restricted access during specific periods for emergency and service vehicles;
- Part-time pedestrianisation with vehicle access during specific periods, no on-street parking but often with (un)loading bays;
- Traffic calming with widened footpaths and reducing on-street parking but without vehicle access restrictions.

‘Pedestrianisation usually does not target UFT - it is part of more comprehensive urban planning to improve the sustainability and liveability of a certain part in the city’

Pedestrianisation usually does not target UFT. It is part of more comprehensive urban planning to improve the sustainability and liveability of a certain part in the city [Muñuzuri *et al.*, 2013; OECD, 2003]. However, it does affect UFT. Research on the impact of pedestrianisation on UFT is limited. The little literature generally addresses pedestrianisation in relation to UFT in three different ways. First, as a restriction to which exceptions should be given,

especially specific time windows for freight vehicles are discussed in this regard [Maes *et al.*, 2012; MDS Transmodal, 2012; Muñuzuri *et al.*, 2005; Soni and Soni, 2016; Vlaams Instituut voor Mobiliteit, 2010]. Second, as part of a policy package with access restrictions in a wider area such as a congestion charging scheme [Attard and Ison, 2010; Ieromonachou, Potter, and Enoch, 2004; Schmöcker, Fonzone, Quddus, and Bell, 2006]. Finally, as a restriction that could accelerate the change for more sustainable UFT; i.e., the use of an urban consolidation centre (UCC) or the deployment of clean vehicle modes like electric vehicles or (cargo)bikes [Lebeau *et al.*, 2015; Zacharias and Zhang, 2015].

The purpose of this paper is to explore and explain the impact of pedestrianisation on UFT based on existing literature and on examples from other cities. Together with the paper of Kesuru *et al.* [in this Portfolio], this review will help us determine which impacts to monitor and evaluate for the extended pedestrian area in Brussels. Section 1 connects pedestrianisation (and accompanying measures) to dedicated UFT policies. Section 2 reviews the impact of pedestrianisation and related UFT measures on UFT. Finally, this paper concludes with recommendations on how to monitor the impact of the extended pedestrian zone in Brussels on UFT.

‘Most local governments allow vehicles in their pedestrianised areas to facilitate deliveries to businesses and consumers located there, be it only during certain time windows’

1. Pedestrianisation within sustainable UFT policies

Policy makers usually do not pedestrianise to regulate UFT but removing (motorised) traffic from streets obviously has an impact on UFT. Most governments take additional accompanying measures to facilitate UFT in the pedestrian zone. These measures are directly related to pedestrianising that area and are implemented because of it. There are also UFT measures that apply to the city-centre as a whole or even the entire urban area and not only to a few pedestrianised (shopping) streets. These measures are not directly connected to the pedestrianisation but do affect freight vehicle movements within the pedestrian-only streets. In this section, we discuss the connection between UFT measures and pedestrianisation.

Policies aimed at facilitating urban freight transport in pedestrian zones

Time windows

Most local governments allow (freight) vehicles in their pedestrianised areas to facilitate deliveries to businesses and consumers located there, be it only during certain time windows. Morning hours are popular (e.g. between 7am and 11am) because shopping streets tend to be less busy during these hours [Muñuzuri *et al.*, 2005; Quak, 2008]. Other cities open up their pedestrian streets for deliveries twice a day or allow evening and/or night deliveries. In case of full-time pedestrianisation, it means that freight vehicles have an advantage over passenger cars. In case of part-time pedestrianisation, there is no distinction between freight vehicles and passenger cars; they are all granted access during the same time windows. It feels as if delivery time windows in pedestrian zones support UFT but they also have negative implications. Planning of deliveries is complicated because time windows are narrow and overlapping between cities [Quak, 2008]. It forces transport operators to use multiple vehicles to deliver small volumes in different cities. Time windows are also not convenient for receivers that prefer to receive their goods at a certain time of day (e.g. restaurants that are only open at night do not have someone present early in the morning to take deliveries).

Loading and unloading zones

The provision of loading and unloading zones is a second measure to support UFT in pedestrian areas [Muñuzuri *et al.*, 2005]. Governments apply this measure mainly in zones with part-time pedestrianisation and traffic calming measures or at the boundary of a zone with full-time pedestrianisation to facilitate deliveries outside granted time windows. One of the drawbacks of this measure is that other vehicles, particularly passenger cars, occupy these zones [Muñuzuri *et al.*, 2013]. In zones with full-time pedestrianisation, goods vehicles can usually park wherever they want as long as they carry out deliveries at a time when it is allowed.

Exceptions based on vehicle requirements

Some accompanying measures are intended to improve sustainability of UFT and to stimulate alternative ways of delivering. In this case, exceptions are given based on specific (vehicle) requirements. Access can be granted to vehicles with alternative vehicle technologies such as electric vehicles (EV). Support for an urban consolidation centre (UCC), which is a warehouse that is situated in close proximity to the urban area it serves from which consolidated deliveries are carried out, is a concept widely discussed in this regard [Lebeau *et al.*, 2015]. Different degrees of support are possible. Granting licenses to the UCC operator for exclusive distribution in a particular zone is an extreme

measure in this regard. It can, however, be justified when there is a reduction in the number of vehicle movements because UCC vehicles deliver with high load factors. Accompanying measures that stimulate alternative ways of delivering can be controversial as they might benefit certain companies and herewith interfere with the principle of the free market [Kin and Macharis, 2015]. Time windows can also be avoided by deploying vehicles that are admitted 24/7 such as (cargo)bikes and handcarts. In this way, pedestrianisation can stimulate a modal shift towards cleaner vehicles.

General urban freight transport policies

Apart from dedicated measures to facilitate UFT in pedestrian zones, many cities also have general UFT measures that affect UFT in the pedestrian zone as well. What these measures have in common is that they are mostly restrictive and access to a wider area is based on specific vehicle requirements (i.e., access conditions). These measures vary greatly from city to city and their impact mostly depends on the combination of measures as well as on the specific local context and morphology of the urban area. We discuss the three most frequently implemented measures in this section: low emission zones (LEZs), vehicle restrictions based on vehicle size/weight and road charging schemes. The purpose of LEZs is to allow or deny access to a certain area based on emission standards of vehicles [Anderson *et al.*, 2005]. In Europe, there is a classification system for passenger and commercial vehicles based on their maximum exhaust emissions that city governments tend to use to set the boundaries of their LEZs. Today, the classification system ranges from Euro 1 (set in 1993) to Euro 6 (set in 2014); the maximum exhaust emissions of a Euro 6 vehicle are much lower than of a Euro 1 vehicle.

Vehicle size/weight restrictions are implemented to abate the pressure on a sensitive urban environment. However, they can also lead to an increase in the number of freight vehicles, particularly vans. A modification of this measure is a minimum fill rate as a condition to enter the area. The city of Gothenburg tested this measure but abolished it again because too many companies felt it was too difficult to comply with the load factor demand and left the city [Danielis *et al.*, 2010]. Additionally, minimum fill rates are too difficult to verify. The use of a UCC is an interesting option in this regard.

Third, some authorities implement road pricing schemes on (parts of) their territory allowing to internalize external costs of transport [Muñuzuri *et al.*, 2005]. This measure can apply to passenger and freight transport but the rate might depend on certain vehicle characteristics. Well-known cases in this regard are the congestion charging schemes in London and Durham [Ieromonachou *et al.*, 2004;

Schmöcker *et al.*, 2006; European Commission, 2016¹]. Since April 2016, heavy goods vehicles (+3.5t) using Belgian roads also have to pay a road charge, managed by the company Satellic². The charge depends on the Euro norm and the gross weight of the vehicle, the distance driven and the type of road (highway or urban road), detailed on the intraregional website of ViaPass³ [Brussels Hoofdstedelijk Gewest, Waalse Overheidsdienst, 2014; Vlaamse Regering, 2015; Vlaamse Belastingdienst, 2016].

Valletta, the capital of Malta, has been implementing several complementary measures to target congestion, parking problems and promote healthier forms of mobility, particularly walking. It included, amongst others, the introduction of a controlled vehicular access (CVA) system with a road user charge in combination with an extension of the already existing pedestrianised area. The most significant effect was the decrease of the average duration of vehicles that stayed in the toll zone [Attard and Ison, 2010]. Despite additional income for authorities, initially, these measures necessitate considerable investments for monitoring and control in order to enforce the intended purpose. Whereas these measures mostly apply to a wider area than the pedestrianised area located therein, eventually it influences the amount and type of vehicles that enter the pedestrian zone. For example, only allowing vehicles with a EURO 4 norm or higher might lead to an improved air quality in the pedestrian zone, even though there is no change in the number of vehicles.

2. Impact of pedestrianisation and related UFT measures on UFT

How does pedestrianisation affect UFT?

Pedestrianisation affects UFT in two ways. There is an indirect impact when consumers change their behaviour and the pedestrianised area becomes more or less popular. Literature reports increased attractiveness and consumption: turnovers increase but in combination with increased rental costs, this does not necessarily lead to higher profits [Hass-Klau, 1993; Schmöcker *et al.*, 2006; Whitehead *et al.*, 2006]. Higher sales were also reported in a pedestrianised zone in Bangkok [Kumar and Ross, 2006] as well as a significant increase in 'commercial activity' after

¹ European Commission. 2016. Urban Access regulation in Europe. [online]. Consulted on 29/08/2016. Available at: <http://www.urbanaccessregulations.eu>

² Satellic, 2016. The Kilometer Charging System in Belgium. [online]. Consulted on 29/08/2016. Available at: <https://www.satellic.be>.

³ ViaPass. 2016. Viapass kilometerheffing voor vrachtwagens van +3,5 ton vanaf 1 april 2016. [online]. Consulted on 29/08/2016. Available at: <http://www.viapass.be/>

pedestrianisation in a number of other cities [Sastre *et al.*, 2013]. In Brussels, some retailers have been voicing their dissatisfaction with the extended pedestrian zone claiming that sales have been halved ever since [Van Horenbeek, 2016]. This aspect is treated thoroughly in the paper of Boussauw [in this portfolio], however, it should be kept in mind that any change in demand for goods also affects UFT in that area.

Apart from this indirect impact, there is also an obvious direct impact since the access and presence of vehicles in the area is restricted. These restrictions force UFT stakeholders such as transport operators and retailers to change their behaviour. This behaviour change has its consequences for the stakeholder himself in terms of costs or quality of service, but also for society in terms of emissions and congestion. How UFT stakeholders change their behaviour is influenced by:

- **Type of pedestrianisation** [Soni and Soni, 2016]: full-time, part-time or traffic calming (See Introduction).
- **The presence of a UFT policy in the pedestrianised area:** In Section 1 we already explained that pedestrianisation almost never is a stand-alone measure from the perspective of UFT. In most cases, there are dedicated time windows allowing delivery vehicles to enter the area and/or dedicated loading and unloading bays. There are also additional access restrictions that apply to a larger area in which the pedestrianised area is situated. These access restrictions can be based on vehicle type, load factor, fuel type, etc. [Danielis *et al.*, 2010; MDS Transmodal, 2012; Quak, 2008; Verlinde, 2015].
- **Impact of pedestrianisation on passenger transport patterns:** pedestrianisation restricts access for (certain types of) vehicles to a demarcated urban area. These restrictions change traffic flows, congestion, accessibility and modal split in and around the pedestrianised area. The majority of vehicles in a city are passenger vehicles. The share of freight vehicles varies from 10 to 18% and the share of freight vehicle kilometres varies from 7 to 20%, depending on the city where it was measured and which types of vehicles were taken into account [Verlinde, 2015]. This means that pedestrianisation will significantly impact the number and type of passenger vehicles in and around the pedestrianised area [Keseru *et al.*, in this Portfolio]. Furthermore, it is relevant for the impact on UFT as well. When, for example, the number of motorized passenger vehicles in the pedestrianised area significantly drops, loading and unloading a delivery vehicle might become easier.

Which UFT stakeholders change their behaviour as a response to pedestrianisation?

The question that arises is: which UFT stakeholders (are forced to) change their behaviour and what do they do differently when they are confronted with a pedestrianised area? In UFT, we distinguish two types of stakeholders: (1) public stakeholders who do not take an active role in UFT in their city and (2) commercial stakeholders who are not primarily driven by an attractive urban environment [Melo, 2004; MDS Transmodal, 2012]. Commercial stakeholders are involved in supply chains of which the first or last part is taking place in an urban environment [Allen *et al.*, 2000]. They strive to provide the best possible service to their customers at the lowest possible cost [Behrends, 2011; Quak, 2008]. Usually, these actors are private companies organising their own operations as efficiently as possible to cut costs. The most extensive overview of UFT stakeholders and their main interests can be found in the report of MDS Transmodal [2012]. According to them, there are three types of supply chain stakeholders in UFT: shippers, transport operators (own account and third party providers) and receivers (major retailers, shop owners, etc.). This structure is used to list below how commercial stakeholders at the supply side change their behaviour due to pedestrianisation.

‘Transport operators are obliged to operate more and usually smaller vehicles to be able to get all their receivers delivered in time windows’

Shippers

The literature on pedestrianisation and on access restrictions for urban freight vehicles does not explicitly mention that shippers change their behaviour. In UFT, the shipper sends the goods to his client (the receiver) and buys logistics services of the transport operator [Macharis *et al.*, 2012]. His main objectives are successful pick-ups at his premises, low cost deliveries, high level service to his client, and, possibly, green concerns [Macharis *et al.*, 2012]. Pedestrianisation and/or access restrictions do not require him to change his behaviour in order to reach those objectives.

Transport operators

Time windows force transport operators to carry out deliveries in a shorter amount of time, usually in the morning. This means that they are obliged to operate more (and usually smaller) vehicles to be able to get all their receivers delivered in time [Groothedde *et al.*, 2003]. In case of access restrictions based on

vehicle type, emission factors and/or fuel type, transport operators are forced to renew their fleet at a faster pace [Danielis et al., 2010]. Sometimes it also convinces them to switch to a more environmentally friendly vehicle type (e.g. electric tricycles or a mobile depot) [Danielis et al., 2010; Verlinde et al., 2014].

Receivers

There are a lot of different types of time windows, but in a pedestrian zone, vehicles are usually kept out during the busiest shopping hours. In many Italian cities, for example, loading and unloading is allowed between 8am and 11am and between 3pm and 6pm [www.urbanaccessregulations.eu, 2016]. Many receivers prefer to process deliveries themselves or to have it done by one of their staff members [Holguín-Veras, 2006]. When time windows are valid, they can no longer choose the most convenient delivery time. In case of delivery times outside opening hours, they have to make sure that someone is at the shop or they have to make the necessary investments to be able to receive unstaffed deliveries in a safe way [Holguín-Veras et al., 2005].

Which impact areas are relevant when evaluating the impact of pedestrianisation?

During the past 25 years of research into urban freight measures and solutions, various evaluation methods and frameworks were tested and accepted as valuable. European examples are BESTUFS II, CIVITAS PLUS II, FREVUE, NICHES, SMARTFUSION, STRAIGHTSOL, SUGAR, TIDE and TRAILBLAZER. BESTUFS II [2006] was one of the first to use the commonly distinguished pillars of sustainability (environment, society and economy) as backbone for its evaluation framework. STRAIGHTSOL extended this with 'Transport' as a fourth impact area since most UFT measures also impact the performance of the urban (freight) transport system. The transport related indicators should help in understanding to what extent a measure contributes to a more efficient, safe and reliable urban transport system [Balm and Quak, 2012]. In the next paragraphs, we use the same categories to review the literature on the impact of pedestrianisation on UFT.

Transport impact of pedestrianisation

Traffic flows

Literature reports on various impacts of pedestrianisation on traffic flows, acting at different scales:

- As MSD Transmodal [2012], Muñuzuri et al. [2013] and Mintsis et al. [2015] argue, the pedestrianisation of a city centre and the limitation of delivery time windows may concentrate traffic flows during authorized delivery times and on authorized access. Indeed, all freight flows, related to construction activity, deliveries or waste collection, that were

previously spread during the whole day are now concentrated over a limited time.

- Another potential effect is the shift of transit flows on surrounding axes of the pedestrianised area. In consequence, even if freight traffic flows are lower in the pedestrianised area, total freight flows remain equal at the whole city scale [Yannis et al., 2006]. Indeed, required freight flows of the economic activity remain equal [Chiquetto, 1997; Strale et al., 2015].
- At a more refined scale, there may also be short distance reports of traffic and deliveries. Actors located inside the pedestrianised area that have another access outside this area (back door, delivery docks...) will move their deliveries to this *free access*.
- Yiu [2011] states based on a case study in Hong Kong that the rental value of commercial floor space increases by 17% in pedestrian zones. Increasing cost of land causes logistics sprawl, which means that logistics facilities move outside of the city towards more suburban areas [Dablanc and Rakotonavriro, 2010].

Congestion

In line with previous statements, potential impacts of pedestrianisation on congestion are manifold:

- Freight traffic reports on surrounding roads of the pedestrian area may worsen congestion on these axes [Muñuzuri et al., 2013].
- On the other hand, pedestrianised area and its direct access will probably show lower congestion, because of the loss of transit traffic and of double parking on street [Muñuzuri et al., 2013].
- Another potential impact is an increasing congestion during delivery windows [MSD Transmodal, 2012]. Indeed, in many cities, authorised delivery times are concentrated in the morning, before the opening of shops. In the Brussels pedestrian zone, there is a time window for deliveries 4am and 11am. This corresponds to the morning peak hour, when passenger car traffic is at its highest level. Thus, additional freight traffic may worsen road congestion around the pedestrian area.
- City authorities may also decide to extend delivery windows towards, for example, early morning or evening hours. This may counteract the concentration of freight flows during morning peak hour and reduce congestion [MSD transmodal, 2012; Muñuzuri et al., 2013].

Accessibility

Of course, general accessibility of the pedestrian area may be influenced by the elements highlighted in the previous points. A higher congestion and freight traffic around the pedestrian area will negatively influence its accessibility [Muñuzuri et al., 2005;

Bestufs, 2004]. On the other hand, the absence or, at least, the strong decrease of passenger car traffic within the pedestrian area may improve its accessibility. Pedestrian area accessibility is also highly dependent on urban planning within this area [Bestufs, 2004]. The creation of dedicated delivery spaces, within or around the pedestrian area, may improve its accessibility [Yannis *et al.*, 2006]. On the opposite, new street furniture and urban development within the pedestrian area that do not take freight traffic into account may complicate deliveries.

In addition to the previous statements, that may influence the general accessibility to the pedestrian area, there are very specific impacts, depending on the various urban supply chains [Danielis, 2010; Strale *et al.*, 2015]:

- Urban logistics chains that require continuous deliveries thorough the day such as parcel deliveries, spare parts deliveries, or specific retail chains like pharmacies and even horeca (for home deliveries) will have to deal with restricted delivery windows within the pedestrian area [Quak and De Koster, 2006].
- Other specific issue is the case of retail based on heavy goods (furniture, musical instruments, heavy electronics...): both clients and shoppers will have to find new solutions for deliveries (*off shored* warehouses outside the pedestrian area of home deliveries for example).
- Another and very important potential affected activity is the building industry [MSD Transmodal, 2012; Strale *et al.*, 2015]: construction sites require various kinds of deliveries. In particular, they often need continuous deliveries of wet concrete. This product has very stringent delivery and use conditions (less than 100 minutes between its production and its use on the construction site) so building industry will have to deal with new accessibility conditions of a pedestrian area.
- Pharmacies generate many freight vehicle movements. For instance, in Brussels each of the 700 pharmacies receives between 2 and 10 deliveries per day [Nsamzinshuti *et al.*, 2016].

Accompanying measures of the pedestrianisation of city centre may influence its accessibility [MSD Transmodal, 2012; Muñuzuri *et al.*, 2005]. These measures may be night deliveries, very/none restrictive delivery windows, restrictive access for some vehicles, based on their weight, age, emissions...

Modal shift

Potential impacts of pedestrianisation on a modal shift in the sector of freight transport are:

- The use of alternative small capacity vehicles (bikes, delivery tricycles...) for some deliveries within the pedestrian area, possibly in

combination with an urban consolidation centre (UCC) [Verlinde, 2015]. However, this shift may only occur for light freight based supply chains, such as parcel delivery and collection, home delivery of food...

- For other freight flows, modal shift depends on the accompanying policies of the pedestrianisation [Metrofreight, 2015]: restricted access for old/polluting/heavy vehicles, incentive for alternative trucks/vans... Without this kind of measures, modal shift remains limited, because of the absence of profitable alternatives and of the high number of small retailers that have their own independent and competing supply chains.
- New urban developments that reduce the accessibility of pedestrian area for heavy vehicles may also encourage the use of small vans, which is not a positive element for the whole city freight traffic and congestion [Strale *et al.*, 2015].

Parking and delivery areas

The impact of pedestrian area on parking of freight vehicles and delivery spaces is highly dependent on urban planning choices. Of course, integrating dedicated delivery spaces in the pedestrian area will help to organize freight vehicle parking [Muñuzuri *et al.*, 2005, 2013]. Moreover, the absence of private cars will reduce the risk of misuse of these spaces. However, as we indicated, pedestrianisation may also lead to the move of delivery spaces outside the pedestrian area for establishments that have a double access (one inside, one outside the pedestrian area). Of course, transit and/or long time parking of freight vehicles is likely to disappear in the pedestrian area.

Economic impact of pedestrianisation

In this section, we will look at the economic impact of pedestrianisation in the field of UFT. To structure this section, we will look at the economic impact from the perspective of the commercial UFT stakeholders: transport operator and receiver and from the perspective of local authorities.

Transport operator

Many of the impacts already discussed also have an economic impact for transport operators:

- Time windows force transport operators to carry out deliveries in a shorter amount of time, which means they are obliged to operate more vehicles to be able to get all their receivers (in different cities) delivered in time [Groothedde *et al.*, 2003]. In 2003, they estimated the yearly cost-increase due to the existing time-window policies in the Netherlands to be about 270 million euro. In a study on time windows in Flanders, 22 out of 34 interviewed transport operators indicated that access restrictions lead to inefficient urban deliveries [Maes *et al.*, 2012].

- Transport operators might also lose time when they do deliveries outside authorized time-windows. They would have to park their vehicle outside the pedestrian zone and walk to the receiver's premises.
- Access restrictions based on vehicle type, emission factors and/or fuel type, force transport operators to renew their fleet at a faster pace than they would have done if there were no access restrictions [Danielis *et al.*, 2010].
- The impact on congestion and accessibility could lead to time gains/losses, which have an economic impact for transport operators.
- Some transport operators might have to reschedule their route to avoid the pedestrian zone when delivering receivers located outside the pedestrian zone. That would lead to extra fuel consumption and time losses.

Receiver

Not a lot of research has been done on the economic impact of changed delivery routines due to pedestrianisation for receivers. However, research on off-hour deliveries shows that receivers fear an additional cost when delivery times are changed. Many receivers prefer to process deliveries themselves or to have it done by one of their staff members [Holguín-Veras, 2006]. When delivery times change, the delivery time might be less convenient (e.g. at opening time) or there might be a need for unstaffed deliveries which requires additional investments [Holguín-Veras *et al.*, 2005].

Local authorities

There is also an economic impact for local authorities. First, they have to enforce the measure and make sure freight vehicles do not enter the pedestrian zone at non-authorized times. Second, they might have to invest in additional loading and unloading zones or other measures to support urban deliveries in the pedestrian zone.

Environmental impact of pedestrianisation

The environmental impact of a transport measure traditionally concerns the impact in terms of global and local emissions, air quality and noise level [Balm and Quak, 2012]. We can measure this impact, calculate it based on emission factors of vehicles and driven kilometres or model it. When we calculate or model the impact, it is possible to make a distinction between the impact of freight and passenger transport. When we measure it, however, we cannot make this distinction which is why might not be able to make the distinction between passenger and freight transport when measuring environmental impact.

An increase of environmental impact of freight transport is possible in case of pedestrianisation when fewer vehicles enter the zone and/or when more environmentally friendly vehicles are used

and/or when congestion in and around the pedestrian zone decreases considerably. MSD Transmodal [2012], Muñuzuri *et al.* [2013] and Mintsis *et al.* [2015] state, however, that delivery time windows do not necessarily decrease the number of vehicles entering the zone; they only redistribute them and concentrate them in a shorter time period.

It is important to measure environmental impacts in and around the pedestrian area to take into account the displacement of pollution and the shift of transit flows to surrounding streets outside the pedestrian zone [Yannis *et al.*, 2006].

Societal impact of pedestrianisation

The societal impact of a transport measure concerns the acceptability and compliance of a measure and its effects on how people perceive the environment in terms of attractiveness and nuisance [Balm and Quak, 2012]. There is an overlap with the impact on congestion, traffic safety, air quality, etc. However, it also concerns job creation, employee satisfaction, the attractiveness of the area, positive business climate, etc.

To our knowledge, there is no literature on the societal impacts of pedestrianisation in the field of UFT. For most impacts, however, it will again be difficult to make the distinction between the impact of freight and passenger transport when measuring societal impact.

Conclusion and recommendations

This review of international literature on UFT and pedestrian zones, time windows and access restrictions shows a clear impact of pedestrianisation on UFT and illustrates which data are needed to monitor the effects of the Brussels pedestrian zone effectively.

‘The BSI-BCO should monitor two types of impact on UFT: the impact on the transportation system and the impact for the different UFT stakeholders’

Consequently, the Brussels Centre Observatory should include indicators to monitor that impact in Brussels, supplemented with the monitoring scheme proposed by Kesuru *et al.*, [in this Portfolio]. This review also revealed that the amount of dedicated research into the impact on UFT is limited, which means that some of the effects might not have been studied or analysed yet. There have been multiple attempts, however, to develop an evaluation framework for UFT measures that incorporates the

objectives and criteria of all stakeholders. We suggest using one of these frameworks as a starting point to identify which indicators and measurement methods to include in the research programme of the Brussels Centre Observatory.

We identified two types of impact on UFT that the Brussels Centre Observatory should monitor: the impact on the transportation system and the impact for the different UFT stakeholders. The impact of pedestrianisation on the UFT system (e.g. more or

less vehicle kilometres, use of new vehicle types or technologies, etc.) will have its impact on the urban transportation system as a whole and will therefore partially contribute to the transportation system's societal and environmental impacts. How to integrate the societal and environmental impact of a changed UFT system in the Brussels Centre Observatory should be aligned with how societal and environmental impacts of a changed passenger transport system are integrated. The set of indicators



Figure 1. The pedestrian area in Brussels a weekday morning, August 2016

Source : BSI-BCO

suggested in Kesuru *et al.* [in this Portfolio] already includes UFT indicators based on existing European evaluation frameworks for UFT.

The pedestrian zone in Brussels contains a concentration of retailing activities visited by tourists and Belgian citizens (e.g., Rue Neuve and City 2 Shopping mall). In addition, the area contains various small and large office buildings such as the one of the email company bpost or the administration of the Brussels' municipality. Finally, of course, this is also a densely inhabited area. All these actors require and create freight flows.

The extension of the Brussels pedestrian area changed the context for UFT in that area. First, there are new time windows for deliveries [Brussel-Stad, 2016]. At the time of writing, deliveries in the Brussels pedestrian area are only allowed between 4am and 11am. The original plan was to limit the delivery window between 6am and 11am but retailers requested an extension. Secondly, the extension of the pedestrian area implies new traffic regulations and the implementation of passes that authorize access to it [Brussel-Stad, 2016]. These passes are free but not everyone can get one. The Brussels municipality is responsible for managing and issuing the passes. Some users are allowed to access the pedestrian area *without a pass* (only freight transport related exceptions are listed):

- For deliveries, between 4am and 11am (during this time window, access terminals are open);
- Vehicles related to monitoring, control and maintenance of the pedestrian area and vehicles used for the collection of refuse.

Some users may access to the pedestrian area *with a pass* (only freight transport related exceptions are listed):

- Vehicles of commercial enterprises whose headquarters is located in the pedestrian area and whose main activity is related to deliveries;
- Itinerant traders engaged in periodic or continuous activity in the pedestrian area;
- Removal services;
- Vehicles carrying out work in the pedestrian area.

Other freight transport vehicles are not allowed to access the pedestrian area.

Apart from the adapted regulations that are already in place and described above, there are other, planned, developments in the pedestrian area of which we expect that they will also change UFT. First, all the entrances of the pedestrian area will be equipped with access terminals, giving access to authorized users and during authorized time windows [Brussel-Stad, 2016]. In addition, city authorities will refurbish the Boulevard Anspach and Rue du Midi [cf. Vanhellement, *et al.*, and Corijn, *et al.*, in this Portfolio]. During refurbishment works, there will be temporary delivery spaces and a 6-metre wide

lane will be kept for deliveries, taxis and other authorized vehicles. The authorities also plan to introduce a UCC during the refurbishments. The objective is to consolidate and pool deliveries for retailers located in the pedestrian area. The last point is the management of the redevelopment works period. A dedicated communication channel will be implemented for explaining and discussing the new developments with retailers and other relevant stakeholders. The refurbishment works will be divided into sections, in order to keep at least one lane per street for deliveries and other authorized vehicles [Brussel-Stad, 2016].

We have some specific recommendations on how to collect necessary data to monitor the impact of the pedestrian zone on UFT in Brussels:

- Traffic counts on the surrounding roads of the pedestrian area and, specifically, on the roads between the pedestrian area and the canal:
 - a. To measure the potential displacement of vehicles on roads around the pedestrian area. Indeed, these are urban zones where additional freight flows may be very harmful. In addition, the canal axle acts as a logistics and wholesale trade hub at the Brussels level [Strale *et al.*, 2015]. Important freight flows are transported along this axle and the pedestrian area may counteract this traffic;
 - b. To measure the impact on congestion by comparing freight traffic counts around the pedestrian zone before and after its extension.
- Traffic counts at the entrances of the pedestrian zone:
 - a. To measure the impact of the pedestrian area on the number of freight vehicles it is attracting;
 - b. To analyse modal shift.
- A survey among a representative sample of goods receivers within the pedestrian area
 - a. To analyse how accessible these establishments still are to transport operators and users. It may be useful to make a specific analysis of the consequences of the pedestrian area on building industry, because of the important role of this activity, regarding urban economy and freight flows;
 - b. To identify potential users of new types of delivery vehicles.
- A field study of the available loading and unloading areas and their accessibility.

The second type of impact is the impact for the different UFT stakeholders. We propose to monitor carefully: (1) how commercial stakeholders (have to) adapt their behaviour and (2) what that means for them. This impact can be evaluated through a survey among a representative sample of establishments

within the pedestrian area and among a representative sample of transport operators entering the pedestrian area.

The above recommendations require an extensive and probably expensive data collection plan: multiple traffic counts and surveys among different stakeholder groups. We also have to be careful not to survey receivers and transport operators too much.

Therefore, it would be interesting to replace the traditional data collection methods with smart data collection methods like participatory sensing, combining large data sets (big data analytics), etc.

Finally, it would also be useful to compose a catalogue of new UFT solutions adopted in the Brussels pedestrian area since its test-extension in June 2015.

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