Introduction

Freight transport's externalities have undesirable impact on the environment of which one prominent is greenhouse gas (GHG) emissions and under the Paris agreement EU union has target to reduce it by 60-80% in 2050 compared to 1990 levels and freight transport will have to deliver its share (Enei, 2010; Bauer et al., 2010). This report discusses freight transport decarbonisation roadmap for EU union. In section-1, how long-distance freight movement (> 300km) with modal shift to less carbon intensive modes by linking rail to ports and business model improvements. Section-2, achieving zero emission urban logistics through integration with existing public transport networks and leveraging electric vehicles. Section-3, improving interaction between long distance and urban freight movements with measures of inclusion of mobile depots and temporal parking spots through urban planning.

Section-1

Average emission factor (gCO_2/tonne-km) for road transport is 62 in comparison for rail is 22, intermodal road-rail is 26 making a case for rail to take a bigger share of freight movements to meet future GHG reduction targets (ECTA and Cefic, 2011). Availability of appropriate infrastructure (eg; rails access to ports with hinterland terminal connectivity) can be a constrain to promote modal shift (McKinnon, 2010). During the period of 2007-2013 infrastructure spend for rail were either at par to road and in some cases less as shown in fig-1 and within the rail infrastructure spending very little investments were made to connect ports as shown in fig-2 which handle large volumes of freight. With accessibility of rail at port and sufficient hinterland access via hinterland terminals, transport links results in increased market access for rails to serve and achieve modal shift as it is more cost competitive with road for long distance movements (Macharis et al., 2010; Merk and Notteboom, 2015). For example, at Port of Gothenburg everyday 25 shuttles are used to transport freight to 24 destinations in Sweden and Norway reducing 360 trucks per day (Merk and Notteboom, 2015). Also, modelling study in Italy for port of Naples and Sarleno and intermodal port Nola and Marcianise have shown movement of freight by train will result in 12,600 tonnes of CO_2 savings annually (Iannone, 2012). It Is critical to setup a rail network connecting ports and hinterland terminals to move large volumes of freight near inland destinations with minimum environment impact.

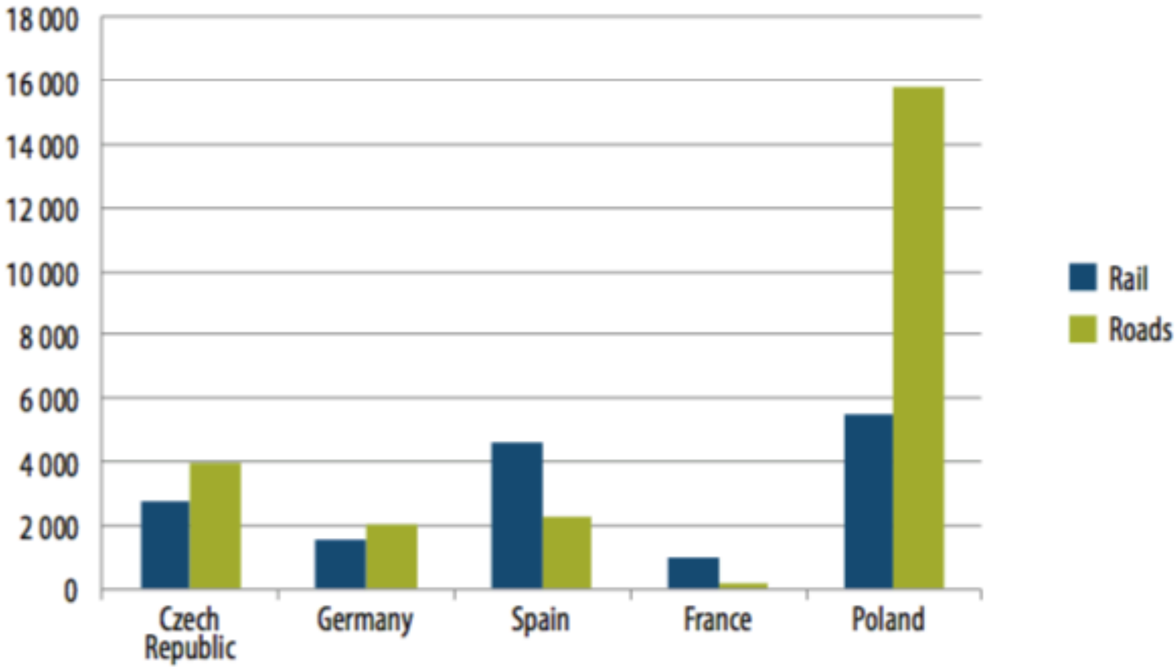

Fig-1 EU funds allocated to rail and roads during 2007-2013 (ECA, 2016)

	Cross-border rail projects						Rail connections to ports					
	ERDF/CF		TEN-T[1]		Total		ERDF/CF		TEN-T		Total	
	Euro	%	Euro	%	Euro	%	Euro	%	Euro	%	Euro	%
France	0	0 %	769	59 %	769	52 %	2.5	1 %	5.8	0.4 %	8.3	1 %
Spain	0	0 %	456	94 %	456	10 %	0	0 %	1	0.2 %	1	0 %
Germany	24	4 %[2]	299	37 %	323	21 %	123	16 %	5.5	0.7 %	129	8.3 %
Poland	35	1 %	0	0 %	35	1 %	1.1	0.1 %	0	0 %	1.1	0.1 %
Czech Republic	343	13 %	0.37	1 %	344	12 %	NA (no seaports)					

Fig-2 EU funds allocated to cross-border rail sections and rail connections to ports during 2007-1013 (ECA, 2016)

Institutional reform by organisation of operations under a single umbrella organisation handling freight movement across the European union will help eliminate barriers to access the freight market amongst the member states if rail were to take higher modal share (Islam, 2014). Requirements of paying higher access charges and taking permissions for accessing tracks with different member state authorities reduces flexibility of operations and affects reliability of rail (Islam, 2014). For example, deadline for a rail freight operator to apply to reserve capacity is 60 days before departure for freight corridor covering Czhech Republic, Greece, Hungary, Austria, Romania and Slovakia while another corridor covering Czhech Republic and Slovakia is 30 days (ECA, 2016). Also, key criteria for carrier selection is reliability based on survey of 25 UK based large shippers (McKinnon, 2014). However, cross border average wait times for rail are 2.5 hrs in western EU to 7 hours in eastern EU (ECA, 2016). In contrast, road freight transport is not affected by cross border delays due to removal or simplification of border control processes and similar strategy for rail freight movement under a single umbrella organisation increasing rails overall reliability, competitiveness and operations (Islam, 2014).

Freight's modal shift to rail can be made more attractive by subsiding/incentivising use of freight trains (Dionori et al., 2015). Polish Rail Transportation, (2012) survey showed high access charge was one of the constrain for modal shift to rail. Reduction in track access charges for freight trains in Germany

(Link, 2018) which was later followed by Dutch government (Van Leijen, n.d.) will required to be adopted by all member states to achieve maximum results as UIRR, (2013) report states 88% of road-rail combined transport shipments went through at least one international border in 2012. Historic withdrawal of rail facilities in Western Europe will also require re-investment and re-commissioning and integrating rail lines to major logistic developments requiring to accommodate new and future freight traffic without affecting passenger traffic which is often prioritised over freight (Mortimer and Islam, 2014).

Railway systems developed in their nation state had strong national imprint embodied from technical components to operating modes including a common language to communicate amongst the staff and freight operators across the border for daily operations (Paye, 2010). Also, diversity of the infrastructure and technology involved in railway operations and railway industry partners continuing to design solutions limited to their products without interoperability as a necessary goal. Resulting in lack of common specifications covering all engineering, operational rules, traffic management and control systems of the network which can be addressed by deploying common standards via legislative actions as recognised by SHIFT2RAIL, (2015) program. One such initiative is EU train driver licensing scheme to address the issue diversity of language and operating mechanism improving interoperability and reliability (RETRACK, 2012).

Section-2

Urban freight transport can be defined as “movement of freight vehicles whose primary purpose is to carry goods into, out and within the urban area” (MDS Transmodal, 2012). Key difference between long distance freight movement and urban freight movement is the involvement of more stakeholders (city authorities, tourists, residents, etc) increasing the complexity for solutions to be deployed along with different types of vehicles required for movement due to diversity of the urban market (Retail and e-commerce, courier, construction, waste, etc) (MDS Transmodal, 2012).

As cities become more urban and metropolitan with rising population there will be a need to expand the current public transport systems cover significant spatial area of the city and can be used to deliver freight (Cochrane et al., 2017). For example, IC:KURIER in Germany uses rail for delivery of courier (up to 20kg) services at 140 location in Germany (Lufthansa Courier, 2016). Further, Matkahuolto in Finland uses intercity and intracity bus services delivering freight to 10,000 locations (Matkahuolto, 2016). Dabbawala in Mumbai, India delivers hot lunch from suburban homes to office workers in Mumbai using its suburban rail network (Patel and Vedula, 2006). Public transit lines can also be used during night time for movement of goods which requires more space or not suitable during day movements (eg; waste) (Cochrane et al., 2017). For example, Mall Haul services in Toronto use subway network outside passenger service hours to supply freight to retailers in downtown Toronto reducing the freight trips generated within urban areas while improving services and economic sustainability of public transit with additional revenue generating trips (Cochrane et al., 2017).

Alternative fuel vehicles like electric vehicles and electric assist freightbikes with zero tail pipe should be used to deliver goods in urban areas as use of public transit network might not necessarily cover all freight deliveries. In Amsterdam a comparison study between use of EURO-4/5 diesel vehicle versus electrical vehicle in similar logistical situation showed net saving in CO_2 emissions was 55,560 kilograms (van Duin et al., 2013). Under Electric Vehicle City Distribution (ECLIDIS) program with trials in Denmark, Germany, The Netherlands, Sweden and UK have shown to be successful and requires to be scaled to reduce CO_2 emissions from urban freight movement with abatement depending on how green the electricity used to charge vehicle batteries (Taefi et al., 2016).

Urban consolidation centres can also help cleaning up emissions from freight, for example, with construction consolidation centre (CCC) in London 70% fewer vehicles make delivery to construction sites and as a result reduction in 75% but also providing commercial benefits by using same vehicle for reverse logistics and higher delivery performance and accuracy (MDS Transmodal, 2012). Similarly Urban Consolidation Centre (UCC) in Dutch cities have reduced truck movement in city which is replaced by electric vans and tricycles/bicycles (van Rooijen and Quak, 2010).

Section-3

Network integration and operations improvements with better interaction of long distance and urban freight can result in to increased efficiency of the overall freight transport network (ALICE, 2014). With a shift from trucks towards rail for long distance freight and using public transport within and around the urban areas will require an open publicly controlled and integrated network with warehouses, hubs and mobile depots to enable consolidation and redistribution in urban areas (ALICE, 2014). For example, TNT express's three month trial in 2013 in Brussels for delivery of parcels and documents from airport to inner city with mobile deports reduced kilometres travelled to 0.52 km per stop from 1.34 km per stop (Verlinde et al., 2014). Also, provisions of space for temporal storage within urban setting would be required which are often limited and expensive to avoid freight vehicles driving unwanted kilometers for finding a place to park get stuck in to traffic jams and contribute to congestion indicating lack of efficiency (ALICE, 2014). These issues can be addressed by integrating requirements of freight flows and corresponding infrastructure inclusion in an urban planning context as was analysed on integrating consumer to consumer and consumer to external flows by Crainic et al., (2004) shifting from current traditional model of regulation on parking, hours of operation and so on.

Along with infrastructure, freight vehicles will require innovative vehicle solutions with provisions of flexibility and modularity to achieve better load factor and interoperability among different transport modes and systems (ALICE, 2014). Further, technologies to transfer loads between large and small vehicles including different transport modes to achieve a holistic multimodal system (ALICE, 2014). For example, InnovaTrain system with 'ContainerMover' system mounted on truck chassis for lifting and horizontal transfer between trucks and train wagons and additional 'ContainerStation' system enabling container storage at yards from wagons with loading/unloading times under 2 minutes (Paddeu et al., 2019).

Along with modal shift to rail but also achieve integration of rails 'terminal-to-terminal' service with 'door-to-door' logistics operators as nature of destination, shipment size, frequency, freight type (eg; flowers, automotive parts, etc) will require multimodal transport and this can be achieved by sharing responsibilities under a single contract with above mentioned provisions of infrastructure and new vehicle technologies (Islam, 2014). Cities can use variety of policy instruments to promote sustainable business practices to create market force for shift to sustainable modes of delivery within city. For example, IKEA's voluntary use of electric truck for all its delivery within Shanghai and plans to deliver items worldwide by 2025 in all cities (Anzilotti, 2019) and using IKEA trains for long haul movements (Woxenius and Barthel, 2002).

Information and Communication Technology (ICT) will be crucial to integrate proposed solutions amongst various actors of supply chain and limitations to afford ICT infrastructure and lack of human resource in smaller organisation size (Harindranath et al., n.d.), lack of standardization and data transparency affecting integration of ICT systems and harmonisation with different policies and guidelines among EU member states (Tsamboulas et al., 2007) will require collaboration efforts within industry and government for effective policy structure and guidelines to be in place. for example, CILLOX, a platform-based business model reduces transaction costs amongst the participants of the supply chain improving rail freight visibility, reducing administration costs, processing times, increasing load factor strengthening the intermodal road-rail model operating in 17 countries integrating 4900 carriers (Meyer et al., 2018).

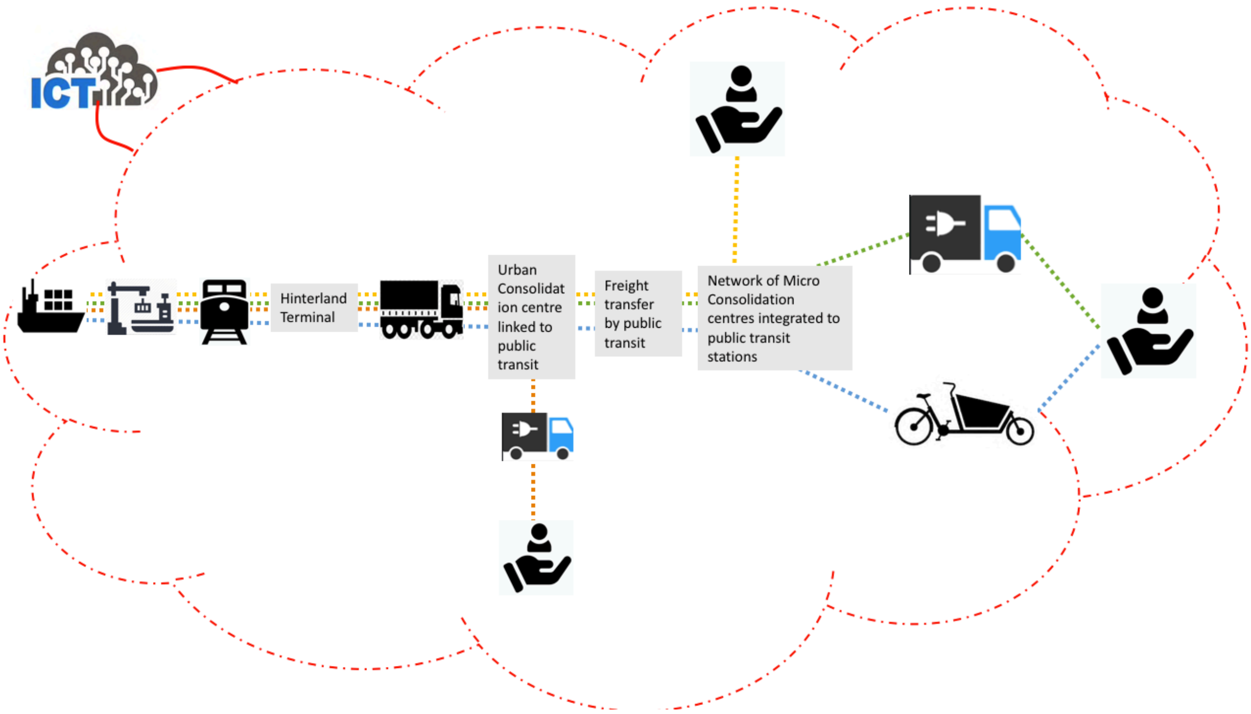

Fig-3 System of freight movement involving freight movement from ports to customer in cities(FlatIcon, 2019; Shutterstock, 2019; VectorStock, 2019; Haashe, 2019; AdobeStock, 2019; Iconfinder, 2019)

Above discussed actions will take time to implement and reach its full decarbonisation potential thus, it is vital that we also scrutinise the current supply chain network. Infrastructure decisions in efforts to decarbonize the freight industry would require curbing of 'logistic sprawl' (spatial deconcentration of logistic terminals in metropolitan areas). For example, between 1974-2008 logistic sprawl in Paris was responsible for net addition of 15,000 tonnes of CO_2 (Dablanc and Rakotonarivo, 2010). Reductions can further be achieved by 'despeeding' of trucks and deep sea container ships which has abatement potential of 171 Mt CO_2e (WEF, 2011).

Conclusion:

Success of decarbonisation of freight transport with the above discussed suggestions will depend on collaboration among logistics, technology and policy stakeholders with political will and policy framework as key components.

References:

AdobeStock 2019. Ict Cloud photos, royalty-free images, graphics, vectors & videos. *Adobe Stock*. [Online]. [Accessed 6 May 2019]. Available from: https://stock.adobe.com/uk/search?k=ict+cloud.

ALICE 2014. *Urban Freight Research and Innovation Roadmap* [Online]. Europe: Alliance for Logistics Innovation through Collabration in Europe. [Accessed 29 April 2019]. Available from: https://www.etp-logistics.eu/wp-content/uploads/2015/08/W56mayo-kopie.pdf.

Anzilotti, E. 2019. In Shanghai, every Ikea delivery is now made with an electric vehicle. *Fast Company*. [Online]. [Accessed 1 April 2019]. Available from: https://www.fastcompany.com/90297201/in-shanghai-every-ikea-delivery-is-now-made-with-an-electric-vehicle.

Bauer, J., Bektaş, T. and Crainic, T.G. 2010. Minimizing greenhouse gas emissions in intermodal freight transport: an application to rail service design. *Journal of the Operational Research Society*. **61**(3), pp.530–542.

Cochrane, K., Saxe, S., Roorda, M.J. and Shalaby, A. 2017. Moving freight on public transit: Best practices, challenges, and opportunities. *International Journal of Sustainable Transportation*. **11**(2), pp.120–132.

Crainic, T.G., Ricciardi, N. and Storchi, G. 2004. Advanced freight transportation systems for congested urban areas. *Transportation Research Part C: Emerging Technologies*. **12**(2), pp.119–137.

Dablanc, L. and Rakotonarivo, D. 2010. The impacts of logistics sprawl: How does the location of parcel transport terminals affect the energy efficiency of goods' movements in Paris and what can we do about it? *Procedia - Social and Behavioral Sciences*. **2**(3), pp.6087–6096.

Dionori, F., Casullo, L., Ellis, S., Ranghetti, D., Bablinski, K., Vollath, C. and Soutra, C. 2015. FREIGHT ON ROAD: WHY EU SHIPPERS PREFER TRUCK TO TRAIN. , p.78.

van Duin, J.H.R., Tavasszy, L.A. and Quak, H.J. 2013. Towards E(lectric)- urban freight: first promising steps in the electric vehicle revolution.

ECA 2016. *Special Report: Rail Freight Transport in the EU- Still not on the Right track* [Online]. Luxembourg: European Court of Auditors. [Accessed 31 March 2019]. Available from: https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf.

ECTA and Cefic 2011. *Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations* [Online]. Europe. [Accessed 31 March 2019]. Available from: https://www.ecta.com/resources/Documents/Best%20Practices%20Guidelines/guideline_for_measuring_and_managing_co2.pdf.

Enei, R. 2010. *EU Transport GHG: Routes to 2050?* [Online]. [Accessed 30 March 2019]. Available from: http://www.eutransportghg2050.eu/cms/assets/EU-Transport-GHG-2050-Report-III-Task3-Paper-Annex-Transport-Trends+Drivers-08-02-10-FINAL.pdf.

FlatIcon 2019. Customer free vector icons designed by Freepik. *Flaticon*. [Online]. [Accessed 4 May 2019]. Available from: https://www.flaticon.com/free-icon/customer_686348.

Haashe 2019. Freight Ship Icon on Hasshe Images. *Hasshe*. [Online]. [Accessed 4 May 2019]. Available from: http://hasshe.com/freight-ship-icon-5b7a89cd2756dd6f6c7e852d/.

Harindranath, G., Dyerson, R. and Barnes, D. n.d. ICT in Small Firms: Factors Affecting the Adoption and Use of ICT in Southeast England SMEs. , p.13.

Iannone, F. 2012. The private and social cost efficiency of port hinterland container distribution through a regional logistics system. *Transportation Research Part A: Policy and Practice*. **46**(9), pp.1424–1448.

Iconfinder 2019. 'Logistic and Delivery (Solid)' by bamicon. *Iconfinder*. [Online]. [Accessed 4 May 2019]. Available from: https://www.iconfinder.com/icons/2574057/container_crane_logistic_port_icon.

Islam, D.M.Z. 2014. Barriers to and enablers for European rail freight transport for integrated door-to-door logistics service. Part 2: Enablers for multimodal rail freight transport. *Transport Problems*. **9**(4), pp.5–13.

Link, H. 2018. *Track access charges: reconciling conflicting objectives Case Study – Germany* [Online]. Berlin: German Institute for Economic Research. [Accessed 2 April 2019]. Available from: https://www.cerre.eu/sites/cerre/files/180509_CERRE_TrackAccessCharges_CaseStudy_Germany_Final.pdf.

Lufthansa Courier 2016. *time:matters - ic:kurier - When every second counts. Your urgent shipment by rail!* [Online]. Germany. [Accessed 2 April 2019]. Available from: https://www.time-matters.com/transport-solutions/ickurier/.

Macharis, C., Van Hoeck, E., Pekin, E. and van Lier, T. 2010. A decision analysis framework for intermodal transport: Comparing fuel price increases and the internalisation of external costs. *Transportation Research Part A: Policy and Practice*. **44**(7), pp.550–561.

Matkahuolto 2016. FAQ/Parcel Services. *Matkahuolto*. [Online]. [Accessed 2 April 2019]. Available from: http://www.matkahuolto.fi/en/parcel-services/faqparcel-services/.

McKinnon, A. 2010. GREEN LOGISTICS: THE CARBON AGENDA. *Green Logistics*., p.9.

McKinnon, A. 2014. Options for Reducing Logistics-related Emissions from Global Value Chains. *Robert Schuman Centre for Advanced Studies*.

MDS Transmodal 2012. *DG MOVE European Commission: Study on Urban Freight Transpor* [Online]. MDS Transmodal Ltd and Centro di ricerca per il Trasporto e la Logistica (CTL). [Accessed 31 March 2019]. Available from: https://ec.europa.eu/transport/sites/transport/files/themes/urban/studies/doc/2012-04-urban-freight-transport.pdf.

Merk, O. and Notteboom, T. 2015. *Port Hinterland Connectivity* [Online]. Paris: International Transport Forum. Available from: https://www.itf-oecd.org/sites/default/files/docs/dp201513.pdf.

Meyer, N., Horvat, D., Hitzler, M. and Doll, C. 2018. Working Paper Sustainability and Innovation No. S 08/2018. , p.32.

Mortimer, P. and Islam, D.M.Z. 2014. A comparison of North American and European railway systems – a critique and riposte. *European Transport Research Review*. **6**(4), pp.503–510.

Paddeu, D., Calvert, T., Clark, B. and Parkhurst, G. 2019. *New Technology and Automation in Freight Transport and Handling Systems* [Online]. Bristol: University of West Bristol. [Accessed 31 March 2019]. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/781295/automation_in_freight.pdf.

Patel, N. and Vedula, N. 2006. Dabbawalas of Mumbai. *Kenan-Flagler Business School*.

Paye, S. 2010. Standardising European railways : a supranational struggle against persistent national languages and emergent local dialects. *Flux*. **n° 79-80**(1), pp.124–136.

Polish Rail Transportation 2012. *Polish Railways in 2012 – market operation and traffic safety* [Online]. Poland: Office of Rail Transportation. [Accessed 30 March 2019]. Available from: https://utk.gov.pl/download/3/7380/raportv2ENfullres.pdf.

RETRACK 2012. *RETRACK Final Report- REorganization of Transport Networks by Advanced Rail freight Concepts* [Online]. Delft: TNO. [Accessed 31 March 2019]. Available from: http://www.retrack.eu/site/en/documenten.php.

van Rooijen, T. and Quak, H. 2010. Local impacts of a new urban consolidation centre – the case of Binnenstadservice.nl. *Procedia - Social and Behavioral Sciences*. **2**(3), pp.5967–5979.

SHIFT2RAIL 2015. *Innovation Programme 2* [Online]. Brussels. [Accessed 31 March 2019]. Available from: https://ec.europa.eu/transport/sites/transport/files/modes/rail/doc/2015-03-31-decisionn4-2015-adoption-s2r-masterplan.pdf.

Shutterstock 2019. Cargo Bike. *Shutterstock.com*. [Online]. [Accessed 4 May 2019]. Available from: https://www.shutterstock.com/image-vector/cargo-bike-419864965.

Taefi, T.T., Kreutzfeldt, J., Held, T., Konings, R., Kotter, R., Lilley, S., Baster, H., Green, N., Laugesen, M.S., Jacobsson, S., Borgqvist, M. and Nyquist, C. 2016. Comparative Analysis of European Examples of Freight Electric Vehicles Schemes—A Systematic Case Study Approach with Examples from Denmark, Germany, the Netherlands, Sweden and the UK *In*: H. Kotzab, J. Pannek and K.-D. Thoben, eds. *Dynamics in Logistics* [Online]. Cham: Springer International Publishing, pp.495–504. [Accessed 2 April 2019]. Available from: http://link.springer.com/10.1007/978-3-319-23512-7_48.

Tsamboulas, D., Vrenken, H. and Lekka, A.-M. 2007. Assessment of a transport policy potential for intermodal mode shift on a European scale. *Transportation Research Part A: Policy and Practice*. **41**(8), pp.715–733.

UIRR 2013. *UIRR - International Union for Road-Rail Combined Transport - Annual reports* [Online]. Brussels: International Union of Road and Rail Combined Transportation. [Accessed 9 April 2019]. Available from: http://www.uirr.com/en/media-centre/annual-reports/annual-reports/mediacentre/575-annual-report-2012-13.html.

Van Leijen, M. n.d. Dutch track access charges to be lowered to 'German level'. *RailFreight.com*. [Online]. [Accessed 3 April 2019]. Available from: https://www.railfreight.com/business/2018/06/19/dutch-track-access-charges-to-be-reduced-to-german-level/.

VectorStock 2019. Electric Truck Flat Icon vector image on VectorStock. *VectorStock*. [Online]. [Accessed 4 May 2019]. Available from: https://www.vectorstock.com/royalty-free-vector/electric-truck-flat-icon-vector-11459665.

Verlinde, S., Macharis, C., Milan, L. and Kin, B. 2014. Does a Mobile Depot Make Urban Deliveries Faster, More Sustainable and More Economically Viable: Results of a Pilot Test in Brussels. *Transportation Research Procedia*. **4**, pp.361–373.

WEF 2011. *Supply Chain Decarbonization* [Online]. Geneva: World Economic Forum. [Accessed 1 April 2019]. Available from: http://www3.weforum.org/docs/WEF_LT_SupplyChainDecarbonization_Report_2009.pdf.

Woxenius, J. and Barthel, F. 2002. International congress on Freight Transport Automation and Multi- modality, Delft, 23 & 24 May 2002.