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Declaration:

I, Alice Bulpin, declare that I have written this dissertation; 'An Exploration of the Benefits of Freight on Transit in Green Supply Chain Management', for the award of MSc International Logistics and Supply Chain Management at the University of South Wales. This dissertation is a result of my own investigation, except where otherwise acknowledged.

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Contents:

Abstract:

The aim of this empirical research study is to understand the managerial considerations associated with freight on transit (FOT) in the movement of low-density high-value (LDHV) goods into urban areas. This research was undertaken because there is an increase of the movement of LDHV goods into urban areas and there are many issues faced by the transport industry to undertake these movements, including road congestion and environmental concerns. This is due to certain factors such as the growth of populations within urban areas and the growth of e-commerce. One opportunity identified to better move LDHV goods into urban areas is FOT, which is the movement of goods on public infrastructure and/or public vehicles. In the context of this research study, FOT relates to the movement of goods using rail infrastructure and/or rail passenger vehicles, including light and heavy rail. This researched is needed because there is a clear paucity of empirical studies which explore the characteristics of FOT. This empirical research study fills this paucity within the literature and contributes to both theory and practice, to encourage the adoption of FOT so that customers can benefit from the advantages that FOT can offer.

This empirical research study collated qualitative data through 13 semi-structured interviews and five in-depth questionnaires with experts from passenger transport and freight distribution, to explore the characteristics of FOT in practice and understand the managerial considerations. The data gathered from the interviews and questionnaires were analysed through thematic analysis, this data set produced 600 codes which were then categorised into themes to understand the benefits, challenges, and opportunities within FOT. This data was then analysed to contribute to theory and practice.

This empirical research has found that there are many benefits, challenges, and opportunities of FOT, which should be used in practice to increase the adoption of FOT to move LDHV goods into urban areas. The specific contributions to practice include the use of stations to facilitate FOT, including the use of empty retail units for storage and distribution of goods which are moved by FOT. Secondly, FOT should be utilised post the coronavirus pandemic for increased resource utilisation and revenue, because the drop in passenger numbers creates capacity and opportunity for freight on passenger services and express logistics. Furthermore, FOT should be adopted because it is efficient, reliable, profitable and not complicated, as they are managed through specialist FOT operators. A final contribution to practice is the connection between FOT and last-mile distribution, this research found that there are many options to facilitate this including cargo bikes, electric vehicles and even drones. Additionally, this study also contributes to theory, as it is thought to be the first empirical study to recognise the environmental benefits of FOT. The researcher also found that FOT is not a well-recognised term in practice and is too generic; therefore, another contribution to theory is the identification of classifications for FOT. The research found that there are two classifications for FOT: express logistics and freight on passenger services.

Introduction:

Title – An Exploration of the Benefits of Freight on Transit in Green Supply Chain Management

Problem Statement:

Moving the increasing amount of goods into urban areas is challenging for freight providers, a solution is needed to move these goods in a more efficient and sustainable way.

Rationale:

Freight transport is vital for the competitiveness and growth of an economy (EUR-Lex,2020) and urban logistics is essential for cities to functions (ITC,2017; RPA,2016). There is an increase in urbanisation and population growth within urban areas (Transport Decarbonisation Alliance,2021), approximately 80% of the population lived in urban areas in 2020 which has risen (ERTRAC, 2015; RPA,2016) and expected to grow further (RPA,2016). This growth is driving the increasing demand for goods into urban areas (RPA,2016) largely due to the increase in online sales and the demand for next or same day delivery, which is increasing the amount of single-item deliveries (Supply Chain Transportation & Logistics Centre,2020). These issues are having an impact on freight operators and society. Urban freight transport is impactful and challenging in many ways, due to congestion, traffic safety, pollution, and emissions (Transport Decarbonisation Alliance,2021). These challenges are leading to an increase in policies restricting urban freight distribution (ITC,2017). There is also a lot of pressure on the transport industry because it contributes to a quarter or carbon emissions (Department for Transport, 2020; European Commission, 2020) and between 30-50% of other transport pollutants. Urban freight is responsible for 25% of urban-related C02 emissions (ERTRAC, 2015) and the primary cause of air pollution in cities (European Commission,2020). An area that has gained recent interest due to the increase in freight in urban areas is freight on transit (FOT). FOT is the movement of goods using public vehicles and/or infrastructure (Cochrane *et al.,*2017; Ozturk and Patrick,2018; Amaral *et al.,*2018; Galkin *et al.,*2019); in this research FOT will specifically refer to FOT using rail infrastructure and vehicles. FOT ranges from attaching freight trailers to passenger services (Cochrane *et al.,*2017; Liang and Tan,2019; DeLanghe *et al.,*2019), moving goods alongside passengers, or operating freight vehicles in between passenger services (Cochrane *et al.,*2017), depending on demand (Liang and Tan,2019; DeLanghe *et al.,*2019). FOT is an innovative solution to optimise resources (Mazzarino and Rubini,2019) and can be used to exploit underutilised capacity of passenger trains (Cochrane *et al.,*2017; Behiri, Belmokhtar-Berraf and Chu,2018) and rail systems (Zhao *et al.,*2018; DeLanghe *et al.,*2019; VanDuin *et al.,*2019; Jiang *et al.,*2020).

Cities are the centre of economies and society, the movement of goods into cities is essential (Cochrane *et al.,*2017; Khan and Khan,2020; Singh and Gupta,2020). Urban freight is necessary for social and economic development (Behiri, Belmokhtar-Berraf and Chu,2018), it improves the economic and competitiveness of a city (Hu *et al.,*2020b). Urban areas have seen the biggest growth (Perera, Thompson and Wu,2020; Hu *et al.,*2020a), with further growth predicted (Behiri, Belmokhtar-Berraf and Chu,2018; Fan *et al.,*2019; Perera, Thompson and Wu,2020). The increase in demand for commodities in urban areas (Horl *et al.,*2016) is creating the need to improve efficiency and sustainability in urban areas (Hu *et al.,*2020b), because freight logistics within cities is unsustainable; economically, socially and ecologically (Kijewska, Iwan and Korczak,2019). The management of urban freight is challenging (Janjevic, Knoppen and Winkenback,2019; Cleophas *et al.,*2019), but if efficient and reliable, freight transportation encourages the growth and sustainability of an economy (Kumar and Anbanadam,2020).

There is a consensus that there has been a growth in the transport sector (Sun *et al.,*2018; Mizutani and Fukuda,2020), for both passengers and freight (Fisch-Tomito and Guivarch,2019; Li and Zhang,2020b). This growth is due to globalisation (Sun *et al.,*2018), continued growth in e-commerce (Rosano *et al.,*2018; Sun *et al.,*2020) and container shipping (Woodburn,2017). Growth is putting pressure on the environment (Pietrzak and Pietrzak,2019; Nocera, Pungillo and Bruzzone,2020) and transport networks (Cullinane *et*

*al.,*2017; Singh and Gupta,2020). Sustainable growth is essential (Islam,2018) and can be achieved through efficient use of infrastructure (Michal *et al.,*2017). Efficient, well-established transport networks allow for smooth and cost-effective freight movements (Khan and Khan,2020), which are essential for citizens welfare (Amaral *et al.,*2018).

There is a global interest in sustainability, especially within the transport sector (Cullinane *et al.,*2017; Islam,2018) because transportation is energy intensive (Zhang, Li and Zhang,2019) and a major contributor to carbon emissions (Lin *et al.,*2017; Li and Zhang,2020). Emissions emitted through freight transport are threatening the health of people, including respiratory and cardiovascular problems and even premature death (Pan *et al.,*2019). These increase in emissions is contributing to climate change which is causing extreme weather which negatively impacts on the transport sector (Woodburn,2019). E missions are largely from the road sector, which has the largest market share within freight distribution (Li and Zhang,2020) and growing (Kaack *et al.,*2018). The road sector emits 7-10 times more than rail (Lin *et al.,*2017).

One way to improve the sustainability of the transport sector is the use of rail freight, which is one of most environmentally efficient means of transporting goods, especially over long distances (Department for Transport, 2020; XChange, 2020; Association of American Railroads, 2020; Islam and Eidhammer, 2016). Rail is “the only freight mode where a zero-carbon option is readily available” (Network Rail, 2020, pp. 2). Emissions from rail are 76% lower than road transport when looking at the equivalent freight movements (Department for Transport, 2016). Additionally, there are other wider environmental benefits to rail freight as it reduces road congestion through removing approximately 7 million lorry journeys every year (Department for Transport, 2020).

Although above notes the benefit of rail freight, there is a low uptake; rail freight is responsible for moving approximately 9% of freight in the UK (Department for Transport,2019). Over recent years there has been a decline in the amount of freight moved by rail due to the reduction of coal usage (Department for Transport, 2019; Rail Freight Group, 2019). However, rail has increased the amount of non-coal freight, such as construction (68% increase) and intermodal (31% increase) freight (Department for Transport, 2019). Since 2003 there has been a 74% increase of freight moved per train and a 47% reduction of freight movements, which has allowed additional capacity for other services (Department for Transport, 2020). Yet, there has still been a decline in the amount of freight volume moved. In 2019-20, 16.6 billion net tonnes were moved, which is 5% lower than the 2018-19 figures and the lowest figure in 23 years (ORR, 2020).

Generally, rail freight transports high volume, low value goods (Zunder and Islam, 2017). However, the nature of freight is changing (Islam and Blinge,2017; Zunder and Islam,2018; ORR,2020) and is moving away from hauling goods such as coal and moving more intermodal freight (Western Gateway, 2020); in fact, domestic intermodal freight movements are the most common and accounted for 41% in 2019-20 (ORR, 2020). There is also an emerging freight market, which is rapid logistics; the movement of goods typically using modified passenger trains to carry low-density high-value (LDHV) goods such as parcels into the major urban centres (Network Rail, 2020), these LDHV goods are typically moved by road and make up the majority of freight movements in Europe (Zunder and Islam, 2017). Road transportation is still favoured over rail to move LDHV goods, due to most journeys being relatively short and generally rail only becomes economically competitive with road once distances are over 300km (Zunder and Islam, 2018).

As noted above, freight cargo is changing (Islam and Blinge,2017; Zunder and Islam,2018; ORR,2020). LDHV goods require reliable, fast movements (Islam and Zunder,2018; Zunder and Islam,2018) and a high level of performance (Woodburn,2019). Freight operators must respond to this demand (Islam and Blinge,2017). The increase in movements of LDHV goods is partially due to the growth of online shopping (Islam,2018). Road operators have been quicker to respond than other modes, like rail, and therefore road moves the majority of these LDHV goods (Islam and Zunder,2018; Zunder and Islam,2018; Islam,2018; Kaack *et*

*al.,*2018), whereas rail is still preferred for moving bulk materials (Zhang, Li and Zhang,2019). Yet, others argue that rail is capable of moving LDHV goods quickly (Woodburn,2019).

There is little research into FOT or the distribution of LDHV goods using urban transport networks (Rai, Verlinde and Macharis,2019; Perera, Thompson and Wu,2020); most research focuses on the movement of passengers (Perera, Thompson and Wu,2020). Due to limited literature of FOT, there is clear paucity of empirical studies that explore the characteristics of FOT.

Aim – The aim of this research study is to explore the managerial considerations associated with freight on transit in the context of the movement of low-density high-value goods into urban areas.

Objectives –

- Provide critical evaluation of the literature around opportunities for the transport and logistics sector to moving LDHV goods into urban areas, including FOT
- To investigate the views of industry experts relating to FOT and its role in moving LDHV goods into urban areas
- To investigate the characteristics of FOT in practice
- To establish recommendations to increase the adoption of FOT

Structure:

The remainder of this dissertation will be split into five chapters. The next chapter is the literature review to assess current literature around this topic. Once the literature is reviewed, the methodology chapter will explain how this research study was conducted. The findings chapter follows the methodology to identify the findings from the primary data. The penultimate chapter is the discussion, this chapter will compare the primary data with the existing literature; to draw a consensus or identify a divergence of data and literature, and to explain how this research contributes to theory and practice. The final chapter is the conclusion to summarise what this empirical research study has found, its contribution and guidance for future research.

Literature review:

Introduction:

It is noted in the literature that freight movements are a necessity, especially within urban areas (Behiri, Belmokhtar-Berraf and Chu,2018; Hu *et al.,*2020b) and there is a growth in urban freight movements (Perera, Thompson and Wu,2020; Hu *et al.,*2020a). This growth is creating issues for freight distribution, including an increase in negative externalities (Guglielminetti *et al.,*2017; Behiri, Belmokhtar-Berraf and Chu,2018) and environmental degradation (Pietrzak and Pietrzak,2019; Nocera, Pungillo and Bruzzone,2020). Additionally, the nature of urban freight is changing to the movement of low-density high-value (LDHV) goods (Islam and Blinge,2017; Zunder and Islam,2018; ORR,2020; Western Gateway,2020), the market for moving these goods is currently dominated by road freight (Zunder and Islam,2017) and a more sustainable mode of freight transportation is needed (Sun *et al.,*2018; Kumar and Anbanadam,2020); such as rail (Woodburn,2017; Wiegmans and Janic,2019). These issues and others will be explored in the first section of this literature review. The second part of this literature review will identify opportunities to combat these issues of transporting LDHV goods into urban areas; including decarbonisation (Kaack *et al.,*2018; Beskovnik and Golnar,2020; Singh and Gupta,2020), modal shift (Lin *et al.,*2017; Cullinane *et al.,*2017; Zunder and Islam,2018; Li and Zhang,2020a) and consolidation (Islam,2018; Ursavas and Zhu,2018). Lastly because there is an emerging market of rapid logistics (Network Rail,2020), this literature review will look specifically at the opportunity of freight on transit (FOT) to address the aim which is to explore the managerial considerations associated with FOT for the movement of LDHV goods into urban areas.

Current issues faced by the transport sector to move LDHV goods into urban areas:

There is a consensus that there has been a growth in the transport sector (Sun *et al.,*2018; Mizutani and Fukuda,2020), and this growth is putting pressure on the environment (Pietrzak and Pietrzak,2019; Nocera, Pungillo and Bruzzone,2020). This is causing a global interest in sustainability within the transport sector (Cullinane *et al.,*2017; Islam,2018; Sun *et al.,*2019; Fan *et al.,*2019). The literature agrees that transportation is very energy intensive (Zhang, Li and Zhang,2019) and a major contributor to carbon emissions (Zhang *et al.,*2017; Lin *et al.,*2017; Sun *et al.,*2018; Fisch-Tomito and Guivarch,2019; Li and Zhang,2020a). These factors are causing a demand for environmentally friendly transport; the transport sector needs to take responsibility for increasing emissions (Sun *et al.,*2018) and their negative externalities (Singh and Gupta,2020; Hu *et al.,*2020b); especially in urban areas (Nocera, Pungillo and Bruzzone,2020). However, a conceptual study found that sustainable urban freight is complex (Canitez,2020). For freight to be sustainable, sustainable modes need to be utilised other than road (Kumar and Anbanadam,2020), because road is the dominant freight mode and creates the largest amount of emissions within transport (Behiri, Belmokhtar-Berraf and Chu,2018; Galkin *et al.,*2019; Li and Zhang,2020a), and growing (Kaack *et al.,*2018). Literature agrees that emissions from freight transport are damaging people's health (Pan *et al.,*2019b; Hu *et al.,*2020b; Minet *et al.,*2020), including respiratory and cardiovascular problems and even premature death (Pan *et al.,*2019b). These increases in emissions are also contributing to climate change (Zhang *et al.,*2017; Woodburn,2019) and causing irreversible damage (Kijewska, Iwan and Korczak,2019). Due to the increased awareness of transport's role in climate change (Pinto *et al.,*2018; Bektas *et al.,*2019), there has been an increase in studies focusing on their environmental management (Pinto *et al.,*2018).

Literature demonstrates that there are further negative externalities created by the transport sector other than emissions (Guglielminetti *et al.,*2017; Behiri, Belmokhtar-Berraf and Chu,2018). Many note that the transport sector, specifically road freight, creates congestion (Guglielminetti *et al.,*2017; Bozejko,2017; Behiri, Belmokhtar-Berraf and Chu,2018; Galkin *et al.,*2019; Singh and Gupta,2020). Conceptual research also found that congestion worsens pollution levels, peoples health and congestion also wastes energy and time (Kijewska, Iwan and Korczak,2019). Another negative externality created by the transport sector noted many times in the literature is accidents (Guglielminetti *et al.,*2017; Behiri, Belmokhtar-Berraf and

Chu,2018; Ozturk and Patrick,2018; Agnieszka and Jagienka,2020). Additionally, congestion and accidents create uncertainty and delays for road transport (Sun *et al.,*2018); making rail a quicker alternative to road (Newman,2020).

Another issue for the transport sector highlighted in the literature is the changing nature of freight cargo (Islam and Blinge,2017; Zunder and Islam,2018). Expectations have changed over time, due to customer requirements (Islam and Blinge,2017; Zunder and Islam,2018); customers' expectations are increasing (Jurczak,2019; Jiang *et al.,*2020). There has been an increase in the movement of consumer goods (Woodburn,2017) and LDHV goods, like parcels, now represent the majority of demand for freight movements (Zunder and Islam,2018). The increase in movements of LDHV goods is partially due to the growth of online shopping (Islam,2018; Liang and Tan,2019; Xie, Wang and Fukuda,2020), which has caused huge demand for express deliveries (Yu *et al,.*2018). An issue is that these goods require reliable, fast movements (Islam and Zunder,2018; Zunder and Islam,2018) at a high level of performance (Woodburn,2019). Freight operators need to respond to this demand (Islam and Blinge,2017) and the distribution of LDHV goods need to be re-thought to be sustainable and to improve urban quality of life (Rai, Verlinde and Macharis,2019). Road freight moves the majority of LDHV goods (Fraga-Lamas, Fernandez-Carames and Castedo,2017; Islam and Zunder,2018; Zunder and Islam,2018; Islam,2018; Kaack *et al.,*2018) and therefore other modes like rail face a lot of competition from road to move these goods (Woodburn,2017) in this competitive market (Islam and Zunder,2018; Kapetanovic, Bojovic and Mikenkovic,2018; Chrislov *et al.,*2019). Rail mainly moves bulk materials (Zhang, Li and Zhang,2019), yet, some empirical research has found that rail is starting to respond to this change and proving that rail can move LDHV goods (Mommens, Lier and Macharis,2020) and quickly (Woodburn,2019).

There are increasing expectations on the transport sector, such as the expectation of door-to-door services; rail has been slow to respond to this demand (Islam and Blinge,2017), whereas road can easily provide a door-to-door service (Zunder and Islam,2018; Ghorpade and Rangaraj,2019). Evidence in the literature also shows that road is more flexible (Muller, Rudolph and Janke,2019) and reliable (Guglielminetti *et al.,*2017; Zunder and Islam,2018). This is supported by empirical studies which note that there is a negative view of rail service quality (Holguin-Veras *et al.,*2021; Woodburn,2019), it is deemed to be less resilient and with fewer diversionary routes compared to road (Woodburn,2019). Rail must improve its service quality to attract more business (Li and Zhang,2020a), especially when competing against road (Guglielminetti *et al.,*2017). To achieve this, investment in rail infrastructure can help achieve better service quality and capacity (Li *et al.,*2020). Also, a conceptual study demonstrates that rail can also provide a quality service through improved flexibility and better facilities and wagons (Zeybek,2018).

Another issue noted by authors is the need for an improvement of infrastructure access, functionality and cargo handling (Zunder and Islam,2018). If terminals are amended to facilitate many types of cargo, it can increase revenue and decrease costs (Bharadwaj,2020). Therefore, investment is needed in rail infrastructure, if not, this can create a barrier of rail use (Kaack *et al.,*2018; Islam and Zunder,2018); transport choices are influenced by the level of infrastructure (Fisch-Tomito and Guivarch,2019). This is supported by conceptual studies which found that infrastructure investment in rail can also encourage usage (Pittman *et al.,*2020; Wei and Chen,2020), but infrastructure is costly (Dick *et al.,*2019) and an obstacle (Kijewska, Iwan and Korczak,2019). Investment needs to come from both public and private sources (Bharadwaj,2020). Investment encourages innovation (Cleophas *et al.,*2019; Muller, Rudolph and Janke,2019) and rapid development of new infrastructure is needed to meet future demand and climate change objectives (Fisch-Tomito and Guivarch,2019). Although, some note that there should be investment in technology rather than infrastructure to reduce constraints, as technology is cheaper and quicker to implement (Standing, Standing and Biermann,2019).

There are other issues within the transport sector which are specific to rail freight, one example highlighted across the literature is the constraints within the rail network (Michal *et al.,*2017; Beskovnik and

Golnar,2020; Bharadwaj,2020). Constraints include bottlenecks (Kaack *et al.,*2018; Mizutani and Fukuda,2020; Pittman *et al.,*2020; Cuppi *et al.,*2021) and insufficient capacity at transport hubs (Chrislov *et al.,*2019; Bharadwaj,2020) and terminals; especially for multimodal rail services (Islam and Zunder,2018). There is also concern as to whether rail has enough network capacity (Sun *et al.,*2018) if there is a large modal shift from road (Lin *et al.,*2017) because many rail networks globally are already at capacity (Cochrane *et al.,*2017; Cleophas *et al.,*2019). It is believed that these constraints are reducing the competitiveness of rail (Pittman *et al.,*2020).

A final challenge specifically for rail is the performance of freight vehicles compared to passenger vehicles (Islam and Zunder,2018; Zunder and Islam,2018). Empirical papers note that passenger vehicles are often prioritised (Islam and Zunder,2018; Zunder and Islam,2018; Woodburn,2019; Ghorpade and Rangaraj,2019; Pittman *et al.,*2020; Miandoab, Ghezavati and Mohammaditabarm,2020) and freight services are scheduled around passenger services (Michal *et al.,*2017). This delays freight and increases fuel consumption (Miandoab, Ghezavati and Mohammaditabarm,2020), and as the number of freight services grow, this increases the risk of delays (Allen and Newmark,2020). However, an empirical study discovered freight vehicles cause a disproportionate amount of delays (Cullinane *et al.,*2017).

Opportunities for the transport sector to move LDHV goods into urban areas:

Decarbonisation and sustainability within transport is difficult to achieve as it relies heavily on fossil fuels (Li and Zhang,2020b). However, conceptual studies note that ways to improve sustainability is through a modal shift and by using low or zero carbon modes (Kaack *et al.,*2018; Beskovnik and Golnar,2020; Singh and Gupta,2020). One example is the use of electric vehicles; however, these require facilities to charge (Hu *et al.,*2020b) and are suggested to be a short-term solution (Muller, Rudolph and Janke,2019). Electric vehicles can be promoted if assets like charging are shared, to make the use of electric vehicles more affordable (Kumar and Jha,2020). Another zero-carbon freight mode is rail (Wiegmans and Janic,2019; Kaack *et al.,*2018; Li and Zhang,2020b), specifically where lines are electrified (Woodburn,2017; Kaack *et al.,*2018) or trains are powered through batteries (Zunder and Islam,2018). Rail powered through electric traction uses the least amount of energy and has little environmental impact (Fan *et al.,*2019). This makes rail more sustainable than other modes like sea which relies on crude oil (Woodburn,2017; Wiegmans and Janic,2019), however, many locomotives still rely on diesel (Mizutani and Uranishi,2020). Literature also notes other developments of different traction methods for rail (Fan *et al.,*2019), such as hydrogen, which would be more cost effective than installing electrification (Kaack *et al.,*2018). Additionally, a conceptual study suggests that hybridised rail locomotives can be used to further enhance rails environmental case (Islam and Zunder,2018). However, to create significant change of transports environmental impact, several measures need to be introduced (Fan *et al.,*2019).

Policies are a tool used to reduce emissions from transport (Wiegmans and Janic,2019; Li and Zhang,2020a; Minet *et al.,*2020; Perera, Thompson and Wu,2020), to make freight sustainable and improve people's health (Pan *et al.,*2019b). Policies to reduce emissions include emission limits (Pinto *et al.,*2018), congestion charging (Canitez,2020), taxing, subsidies (Amaral *et al.,*2018; Li and Zhang,2020a), and rules around the use of heavy-duty diesel engines (Pan *et al.,*2019b; Esposito, Cicatiello and Ercolano,2020); although Kaack *et al.*(2018) found that only a few countries are regulating heavy-duty vehicles. Yet, when policies and taxing on diesel vehicles are implemented it has shown to be effective in reducing emissions from lorries and one way to encourage the use of zero-emission vehicles (Pan *et al.,*2019b). These policies also encourage a shift to rail (Kaack *et al.,*2018; Bektas *et al.,*2019; Li and Zhang,2020a; Li and Zhang,2020b; Esposito, Cicatiello and Ercolano,2020; Cuppi *et al.,*2021) and the use of intermodal (Kaack *et al.,*2018). However, the literature indicates how policies can be used in other ways within transport rather than just reducing emissions. For example, pricing policies can be used to adjust the price to be flexible to demand (Zhang, Li and Zhang,2019; Li *et al.,*2020) and attract customers (Zhang, Li and Zhang,2019); pricing should depend on demand (Li *et al.,*2020). Similarly, it is noted that dynamic (Li and Zhang,2020b) and integrated

pricing and planning can improve competitiveness for rail (Li and Zhang,2020a). However, empirical studies discovered policies often favour passengers over freight (Hu *et al.,*2020b), as freight faces many policies in cities (Behiri, Belmokhtar-Berraf and Chu,2018; Hu *et al.,*2020b), including additional charges, banning polluted vehicles (Behiri, Belmokhtar-Berraf and Chu,2018) and reduced accessibility which is creating congestion and worsening punctuality (Hu *et al.,*2020b). In addition to this, policies to alleviate negative externalities have been ineffective in the past (Janjevic, Knoppen and Winkenback,2019; Akkad and Tamas,2020; Perera, Thompson and Wu,2020; Bruzzone, Cavallaro and Nocera,2021); this may be because stakeholders have not accepted policies (Akkad and Tamas,2020). Yet, an empirical study discovered that successful policies reduces congestion, improve journey times, encourage modal shift and increase revenue for public transport (Canitez,2020).

As stated above, congestion is an issue within the transport industry (Kijewska, Iwan and Korczak,2019; Galkin *et al.,*2019; Singh and Gupta,2020). However, the literature found that rail could be a solution to alleviate congestion (Bozejko,2017; Ozturk and Patrick,2018), as there is little or no congestion on rail, if planned properly (Bozejko,2017). Additionally, the first section of this literature review noted that another negative externality of transport are accidents (Guglielminetti *et al.,*2017; Behiri, Belmokhtar-Berraf and Chu,2018; Ozturk and Patrick,2018; Agnieszka and Jagienka,2020), however, rail is safer than road (Bozejko,2017; Chen *et al.,*2017), especially for hazardous goods (Holguin-Veras *et al.,*2021). Rail can therefore be used to alleviate these negative externalities of congestion and accidents (Ozturk and Patrick,2018).

The environmental issues highlighted by the literature above has created a pressure on freight operators to undertake a modal shift away from road to other modes which are better for the environment and efficient, such as rail (Lin *et al.,*2017; Cullinane *et al.,*2017; Zunder and Islam,2018; Li and Zhang,2020a). Conceptual studies note that rail is an environmentally friendly transport mode (Islam and Zunder,2018; Islam,2018; Zhang, Li and Zhang,2019; Khan and Khan,2020; Miandoab, Ghezavati and Mohammaditabarm,2020) with fewer external costs than road (Kaack *et al.,*2018; Wiegmans and Janic,2019) and key to creating a sustainable transport sector (Islam and Blinge,2017). Rail releases fewer emissions (Lin *et al.,*2017; Li and Zhang,2020a) and can therefore be used as a tool to reduce emissions in the transport sector (Heinold, 2020) and other negative externalities (Woodburn,2017). However, there is a body of research into decreasing emissions from road vehicles (Ferrari,2018; Islam,2018), which is putting pressure on the rail industry (Islam,2018). Also, it is noted that older rail vehicles are costly to society as well as the operator and infrastructure owner, but incentives like increased track access charges can be implemented to encourage the use of better performing rolling stock (Cullinane *et al.,*2017). Conceptual studies note that a complete shift from road to rail is not feasible due to either cost or the lack of access to rail infrastructure (Pinto *et al.,*2018); therefore, subsidies are often used to encourage the shift to rail to reduce emissions (Fan *et al.,*2019).

Additionally, multimodal transport is another opportunity for the transport industry and is key for logistic systems for international and long-distance services (Seo, Chen and Roh,2017). Multimodal has seen the most growth within the transport sector and causing a growth of rail freight (Woodburn,2017). Rail is considered the backbone for multimodal container movements (Sun *et al.,*2018), but multimodal is needed as many rail terminals are not located close to end customers (Mommens, Lier and Macharis,2020). Multimodal transport can meet commercial needs (Islam,2018) whilst also identifying alternative routes which can be used when there's unexpected disruption, and provide multiple route, cost and transit time options (Seo, Chen and Roh,2017). Research found that multimodal movements involving rail can be faster than a single mode, especially over long distances like the Asia-Europe rail link (Kaack *et al.,*2018). Empirical research agrees that multimodal can help achieve efficient (Chen *et al.,*2019; Kumar and Anbanadam,2020; He *et al.,*2021) and sustainable transport through reducing emissions (Zhang *et al.,*2017; Kaack *et al.,*2018; Islam,2018; Pinto *et al.,*2018; Chen *et al.,*2019; Heinold,2020). Additionally, another benefit of multimodal is that it can be used to mitigate against congestion and costs (He *et al.,*2021). Multimodal can take the

advantages of each mode (Zhang *et al.,*2017; Sun *et al.,*2018), but there is still more improvement needed to be more energy efficient and environmentally friendly (Beskovnik and Golnar,2020). Multimodal transport is difficult due to economic, social and political issues (Kumar and Anbanadam,2020) and must remain time and price competitive (Beskovnik and Golnar,2020). However, a benefit of multimodal is that it can reduce the barriers to entry as locomotives and wagons are often rented and multimodal terminals are open access (Crozet,2017). Yet, other empirical literature states that multimodal rail transport can be difficult to implement (Kumar and Anbanadam,2020) and movements can be costly (Islam and Zunder,2018) due to requiring high investments to involve rail in multimodal transport (Beskovnik and Golnar,2020). However, costs can be reduced through increased frequencies and economies of scale (Crozet,2017); yet if not organised well, multimodal can be unreliable and costly (Kumar and Anbanadam,2020). Another issue highlighted in the literature of multimodal activities is the increased risk of damaging and losing goods when moving between modes (Islam,2018; Islam and Zunder,2018; Kumar and Anbanadam,2020); to reduce this risk, goods can be moved between modes through using standardised containers (Seo, Chen and Roh,2017).

An additional opportunity within transport is the consolidation of smaller shipments (Islam,2018; Ursavas and Zhu,2018), to encourage smaller firms use rail freight (Islam,2018). A conceptual study found that consolidation also helps to achieve economies of scale and lower costs (Ursavas and Zhu,2018) because consolidation of goods can reduce the number of vehicles needed (Massson *et al.,*2017). Additionally, third party logistics providers can be used to allow smaller firms to use rail, which is a good opportunity to encourage rail freight growth (Holguin-Veras *et al.,*2021). Technology advances can also help smaller firms to access on-demand rail capacity without the need for third party logistics providers (Standing, Standing and Biermann,2019). Similarly, horizontal logistics can be utilised (Zunder and Islam,2018). Horizontal logistics includes collaborations between firms within a supply chain, for example resource pooling between logistic service providers or shippers, which is an effective solution for sustainable logistics, and has gained interest in recent years (Pan *et al.,*2019a). However, a conceptual study noted that horizontal logistics requires technology interventions (Islam and Zunder,2018). There has been some focus on technology to develop decision making tools for horizontal logistics, but less focus on the managerial issues. Similarly, collaboration can be utilised as an opportunity (Zunder and Islam,2018), conceptual studies found that collaboration can increase revenues (VanDuin *et al.,*2019) through reducing costs by sharing finite resources (Ko *et al.,*2020), whilst also improving efficiency and sustainability (Pan *et al.,*2019a). Although collaboration in transport is increasing (Gonzalez-Feliu Pronello and Salanova-Grau,2018; Melo, Macedo and Baptista,2019) it is still difficult (Gonzalez-Feliu Pronello and Salanova-Grau,2018).

Last-mile delivery is a challenge (Nocera, Pungillo and Bruzzone,2020; Jiang *et al.,*2020), and the most expensive (Rosano *et al.,*2018; Ko *et al.,*2020; Bruzzone, Cavallaro and Nocera,2021) and environmentally damaging part of logistics (Rosano *et al.,*2018; Bruzzone, Cavallaro and Nocera,2021). Last-mile logistics are fragmented and uncoordinated, which creates low utilisation of vehicles and damaging to the environment (Nocera, Pungillo and Bruzzone,2020). The larger the amount of e-commerce, volumes and users, the harder the last-mile delivery (Rosano *et al.,*2018; Bruzzone, Cavallaro and Nocera,2021). However, there are innovation opportunities for the logistics industry and particularly last-mile delivery include drones (Rosano *et al.,*2018; Muller, Rudolph and Janke,2019; Hu *et al.,*2020b), parcel lockers (Rosano *et al.,*2018; Rai, Verlinde and Macharis,2019; Taniguchi, Thompson and Qureshi,2020; Hu *et al.,*2020b), urban consolidation centres, shared logistics (Rosano *et al.,*2018), crowd shipping (Pires *et al.,*2018; Rosano *et al.,*2018; Agnieszka and Jagienka,2020) and electric vehicles (Rosano *et al.,*2018; DeLanghe *et al.,*2019; Taniguchi, Thompson and Qureshi,2020). Conceptual studies found that innovations aim to improve efficiency and sustainability (Rosano *et al.,*2018) and can be encouraged through policies (Rai, Verlinde and Macharis,2019). However, most require road use which is scarce, or their systems are currently insufficient, or there are restrictions on their use, specifically for drones and cargo-bikes (Hu *et al.,*2020b). However, a

way to improve last-mile delivery and freight efficiency is through technological innovation (Hu *et al.,*2020b).

Technology is also noted by many in recent literature as an opportunity to improve the movements goods, including for rail freight (Islam and Blinge,2017; Li and Zhang, 2020a). Rail lacks traceability (Holguin-Veras *et al.,*2021) but customers require the ability to track their goods (Islam and Zunder,2018). Conceptual studies found that using real-time information and technology (Guglielminetti *et al.,*2017) can encourage rail growth (Guglielminetti *et al.,*2017; Li *et al.,*2020) and increase competitiveness (Fraga-Lamas, Fernandez-Caranes and Castedo,2017). Similarly, other conceptual studies noted that technological innovation can encourage a shift to rail, but this requires investment (Zunder and Islam,2018), which has shown to be slow within the rail industry (Islam,2018). Another innovation highlighted by conceptual research is automated transport (Sun *et al.,*2020; Taniguchi, Thompson and Qureshi,2020) which is predicted to be more utilised (Hell and Varga,2018). Automated transport can promote efficiency and sustainability (Taniguchi, Thompson and Qureshi,2020), and reduce the number of accidents (Hell and Varga,2018).

There is also an opportunity to improve freight movements between countries, as literature notes that interoperability (Islam,2018) and freight movements between countries is poor (Jarzemskis and Jarzemskiene,2017). Interoperability is a key challenge for the free flow of rail traffic (Fraga-Lamas, Fernandez-Caranes and Castedo,2017) because incompatibility of infrastructure is a barrier to rail (Bektas *et al.,*2019); railways need to be interoperable across borders to increase its competitiveness (Esposito, Cicatiello and Ercolano,2020). A conceptual study notes that movement between countries can be improved through better data exchange at borders (Abramoviic, Zitricky and Biskup,2016) and through infrastructure improvements (Stepanova *et al.,*2019) to have the capability to operate using multiple tractions and voltages (Zunder and Islam,2018). It is important that interoperability is improved because authors predict that international freight movements are going to increase further (Cullinane *et al.,*2017). There is the potential for increased international rail movements between Europe and Asia (Chen *et al.,*2017; Yang, Pan and Wang,2018; Zhang and Schramm,2020), especially for high value cargo (Chen *et al.,*2017). Opportunities have been created to transport intercontinental cargo via the new Iron Silk railroad (Chen *et al.,*2017; Zhang and Schramm,2020), which has seen significant growth since its completion (Yang, Jiang and Nc,2018; Li *et al.,*2020), and is expected to grow further (Besharait *et al.,*2017). Empirical studies have found that rail freight between Europe and Asia is cheaper than aviation (Li *et al.,*2020; Zhang and Schramm,2020), with higher capacity and twice as fast as freight movement by sea (Zhang and Schramm,2020). The higher capacity creates cheaper costs per unit (Wiegmans and Janic,2019) and because rail is quicker than sea freight (Li *et al.,*2020), this can improve reliability of transport times (Wiegmans and Janic,2019; Li *et al.,*2020) and reduce inventory costs (Wiegmans and Janic,2019; Chen *et al.,*2017). Therefore, rail can rival other freight transport modes for long distance travel (Yang, Pan and Wang,2018; Wiegmans and Janic,2019).

There is a global trend of increasing the speed of good movements (Zhang and Schramm,2020). The increasing speed of rail provides more opportunities (Bharadwaj,2020) and better services for freight movements (Yu *et al,.*2018; Bharadwaj,2020). Conceptual studies note that if goods move quickly this increases its competitiveness against road (Myronenko and Hrushevska,2018); the faster goods move, the faster the return on investment (Bharadwaj,2020). Additionally, literature demonstrates that high speed rail (HSR) encourages modal shift to rail (Myronenko and Hrushevska,2018; Beskovnik and Golnar,2020). HSR is primarily used to move passengers (Watson, Ali and Bayyati,2019) and the increase of speeds for HSR passenger services is creating differences between freight and passenger services, and negatively impacting line capacity (Talebian, Zou and Peivandi,2018); therefore intervals between freight trains need to be considered on HSR networks (Myronenko and Hrushevska,2018). However, there is the possibility of moving containers using HSR networks of over 200km/h (Bushev, Shulman and Sagajdak,2019) and conceptual literature demonstrates that there is an opportunity to move freight on HSR passenger vehicles

(Watson, Ali and Bayyati,2019; Liang and Tan,2019; Gao, Zhang and Goodchild,2020), especially for intercity logistics (Talebian, Zou and Peivandi,2018). Goods using HSR can either be moved on empty inspection trains or companies can reserve whole carriages (Gao, Zhang and Goodchild,2020). Conceptual studies noted that the movements of goods on HSR is cost effective (Watson, Ali and Bayyati,2019; Liang and Tan,2019), profitable (Bushev, Shulman and Sagajdak,2019) and environmentally friendly (Yu *et al,.*2018; Liang and Tan,2019); however, there are problems combining passenger and freight on HSR (Myronenko and Hrushevska,2018). When compared to road and air, HSR is more efficient (Gao, Zhang and Goodchild,2020) due to higher load capacity and faster journey times compared to road. Also, HSR is cheaper than aviation (Liang and Tan,2019) and therefore a threat to air cargo (Watson, Ali and Bayyati,2019; Chen and Jiang,2020).

Rail is becoming competitive and attractive to move freight (Laroche *et al.,*2017); however, rail can increase its competitiveness further through reducing costs (Islam and Blinge,2017; Laroche *et al.,*2017), especially when competing against road (Guglielminetti *et al.,*2017). Conceptual studies note that rail can reduce costs, whilst also improving its competitiveness in many ways, such as universalising gauging, improving terminals (Pinto *et al.,*2018), using longer trains (Islam and Blinge,2017; Beskovnik and Golnar,2020), improved resource and infrastructure utilisation (Islam and Blinge,2017; Fisch-Tomito and Guivarch,2019; Agnieszka and Jagienka,2020), higher speeds (Islam and Blinge,2017), outsourcing crew and maintenance, and leasing vehicles (Laroche *et al.,*2017). An empirical study demonstrates that some of these initiatives have already been used as rail has improved efficiency over recent times, because the number of services hasn't increased, but load capacity has increased through longer trains (Woodburn,2017). However, some efficiency improvements require changes in infrastructure and timetabling (Islam and Blinge,2017). Modelling can be used to assess freight paths in the timetable and can model the impact of infrastructure changes (Michal *et al.,*2017).

Rail should be used as an opportunity to the transport industry because literature states that rail can be competitive on transit time, especially when services are over long distances (Islam and Zunder,2018). However, empirical studies note that performance of rail freight vehicles is a constraint (Islam and Zunder,2018; Zunder and Islam,2018). Freight vehicles need to match the characteristics of passenger vehicles, including speed, breaking and acceleration to increase competitiveness and so that services can be better integrated (Zunder and Islam,2018). A conceptual study found that another opportunity to improve performance and encourage rail freight use is through separate passenger and freight lines (Pittman *et al.,*2020). Yet most countries have integrated infrastructure (Talebian, Zou and Peivandi,2018; Cleophas *et al.,*2019; Pittman *et al.,*2020) because over time freight lines have been converted to passenger lines (Horl *et al.,*2016). Therefore, shared infrastructure needs sufficient planning to ensure optimal use of resources and infrastructure (Ursavas and Zhu,2018). Literature found that policies have be used to segregate freight routes to encourage a modal shift (Singh and Gupta,2020). Separation of services is an opportunity to reduce delays, rather than improving capacity of shared infrastructure (Allen and Newmark,2020). However, separated freight lines can be costly, therefore combining freight and passengers can save on infrastructure costs (Hu *et al.,*2020b; Allen and Newmark,2020).

Literature agrees that investment is needed within rail (Cullinane *et al.,*2017; Zunder and Islam,2018). Investment can be used as an opportunity to improve safety (Fraga-Lamas, Fernandez-Caranes and Castedo,2017), capacity (Fraga-Lamas, Fernandez-Caranes and Castedo,2017; Dick *et al.,*2019; Rosell and Codina,2020), reliability (Dick *et al.,*2019), performance (Hu *et al.,*2020b) and increase competitiveness (Wiegmans and Janic,2019). Empirical studies found that there has been little investment in rail compared to other modes (Islam,2018; Mizutani and Fukuda,2020). However, conceptual studies found that investments could be encouraged through environmental benefit appraisals (Lin *et al.,*2017) or through policies (Wiegmans and Janic,2019). Investment in the railway and their hubs can reduce transit and handling times (Yang, Pan and Wang,2018) and create new transport corridors (Wiegmans and Janic,2019); these efficiencies can encourage rail freight adoption (Rosell and Codina,2020). The higher the investment,

the higher the reduction in negative externalities (Hu *et al.,*2020b), however, this investment requirement makes rail even more costly; empirical studies already agree that rail is costly compared to other modes (Behiri, Belmokhtar-Berraf and Chu,2018; Singh and Gupta,2020).

Freight on transit:

Rail freight has shown potential to handle goods in urban areas (Pietrzak and Pietrzak,2019) and although urban rail infrastructure already exists, it isn't well utilised for freight (Cleophas *et al.,*2019). Currently there is not much research on the distribution of LDHV goods like parcels through urban logistics (Rai, Verlinde and Macharis,2019). Most urban transport studies concentrate on passenger movements (Perera, Thompson and Wu,2020). However, there is growing attention of transporting goods on urban passenger lines (Hu *et al.,*2020b; Xie, Wang and Fukuda,2020; Jiang *et al.,*2020; Agnieszka and Jagienka,2020) and the integration of passenger and freight transport (Cochrane *et al.,*2017; Galkin *et al.,*2019; VanDuin *et al.,*2019; Mazzarino and Rubini,2019), otherwise known as FOT. Many agree that FOT is where freight is carried using public vehicles and/or infrastructure (Cochrane *et al.,*2017; Ozturk and Patrick,2018; Amaral *et al.,*2018; Galkin *et al.,*2019). FOT is an innovative solution to optimise resources (Mazzarino and Rubini,2019). Conceptual studies found that goods can be moved through exploiting underutilised passenger trains (Cochrane *et al.,*2017; Behiri, Belmokhtar-Berraf and Chu,2018) and underutilised capacity on rail systems (Zhao *et al.,*2018; DeLanghe *et al.,*2019; VanDuin *et al.,*2019; Jiang *et al.,*2020). Conceptual studies note that logistic providers in cities need to use this information to rethink the use of existing infrastructure for better utilisation (Cleophas *et al.,*2019). Additionally, literature found that if cities already have the infrastructure of a Metro or light rail system, then there's better feasibility for urban rail freight (Hu *et al.,*2020b). These urban transport systems are accessible, punctual and have large capacity to carry small, time sensitive goods (Zhao *et al.,*2018). Studies note that FOT ranges from attaching freight trailers to passenger services (Cochrane *et al.,*2017; Liang and Tan,2019; DeLanghe *et al.,*2019), moving goods alongside passengers, or operating freight vehicles in between passenger services (Cochrane *et al.,*2017), depending on demand (Liang and Tan,2019; DeLanghe *et al.,*2019). Authors note that attaching freight vehicles to passenger services is the most viable option for FOT (DeLanghe *et al.,*2019; VanDuin *et al.,*2019).

FOT is attractive to the transport sector because the service qualities and travel times are attractive (Mazzarino and Rubini,2019) and it improves competitiveness (Agnieszka and Jagienka,2020) because goods can move quickly and avoid congestion (Pietrzak and Pietrzak,2019). Conceptual studies note FOT as an opportunity to use urban rail freight to transport goods that are time sensitive and high value (Singh and Gupta,2020). Another benefit of FOT mentioned by many conceptual studies is the improvement on the environment and sustainability (Behiri, Belmokhtar-Berraf and Chu,2018; Hu *et al.,*2020b; Singh and Gupta,2020; Jiang *et al.,*2020; Bruzzone, Cavallaro and Nocera,2021), as FOT helps reduce emissions and other negative externalities (Zhao *et al.,*2018; DeLanghe *et al.,*2019; VanDuin *et al.,*2019; Hu *et al.,*2020b) like congestion (DeLanghe *et al.,*2019; Singh and Gupta,2020; Jiang *et al.,*2020). Also, conceptual studies state that FOT can improve reliability (Hu *et al.,*2020b) and efficiency (Fatnassi, Chaouachi and Klibi,2015; DeLanghe *et al.,*2019; Hu *et al.,*2020b; Jiang *et al.,*2020); these improvements also bring economic benefits (Behiri, Belmokhtar-Berraf and Chu,2018) through reduced costs (Jiang *et al.,*2020; Fatnassi, Chaouachi and Klibi,2015; Cochrane *et al.,*2017; Standing, Standing and Biermann,2019; Jiang *et al.,*2020). Additionally, it is stated in conceptual studies that FOT helps with the issue of last-mile distribution (Horl *et al.,*2016; Ozturk and Patrick,2018; DeLanghe *et al.,*2019; Agnieszka and Jagienka,2020; Bruzzone, Cavallaro and Nocera,2021). These benefits of FOT have created growing interest in the use of urban rail networks to move freight into cities (Ozturk and Patrick,2018).

However, there are many issues when implementing FOT and there are only a few practical examples noted within the literature (Behiri, Belmokhtar-Berraf and Chu,2018); most studies are conceptual. Conceptual studies note that FOT is complex (Nocera, Pungillo and Bruzzone,2020; Sun *et al.,*2020), there are operational, organisational (Mazzarino and Rubini,2019; Cleophas *et al.,*2019) and managerial challenges

(Mazzarino and Rubini,2019); although it is argued that institutional barriers are harder than technical challenges (Cochrane *et al.,*2017). Many note the difficulties with combining passenger and freight regulations (Watson, Ali and Bayyati,2019; Bruzzone, Cavallaro and Nocera,2021) and compatibility (Cochrane *et al.,*2017); there should be a unified approach (Mazzarino and Rubini,2019). Conceptual studies noted that infrastructure like parcel hubs are needed in stations (Zhao *et al.,*2018; Jiang *et al.,*2020) and sophisticated operating systems are needed to manage efficient passenger and freight movements (Sun *et al.,*2020). Also, for FOT to work that there must be political will (Mazzarino and Rubini,2019; Nocera, Pungillo and Bruzzone,2020) and government intervention (Sun *et al.,*2020). Additionally, literature notes the difficulty in managing stakeholders' interests (Hu *et al.,*2020b), these stakeholders are both public and private (Janjevic, Knoppen and Winkenback,2019). Another conceptual issue for adoption of FOT is that public networks are slow, unreliable and inflexible (Bruzzone, Cavallaro and Nocera,2021). Conceptual studies suggest that freight should only be carried on passenger vehicles during the off-peaks (Fatnassi, Chaouachi and Klibi,2015; Zhao *et al.,*2018; DeLanghe *et al.,*2019; Sun *et al.,*2020) because passengers should not be disrupted (Cochrane *et al.,*2017; Massson *et al.,*2017). Some argue that the challenges of FOT outweigh the positives (Cochrane *et al.,*2017) and that societal benefits outweigh economic benefits (Cochrane *et al.,*2017; DeLanghe *et al.,*2019). Conceptual studies argue that FOT requires investment (Cochrane *et al.,*2017), is costly (Nocera, Pungillo and Bruzzone,2020), not necessarily sustainable commercially (VanDuin *et al.,*2019) and economic feasibility depends on the amount of cost savings (Amaral *et al.,*2018). FOT must not rely on subsidies and use any profits to improve passenger services (Cochrane *et al.,*2017).

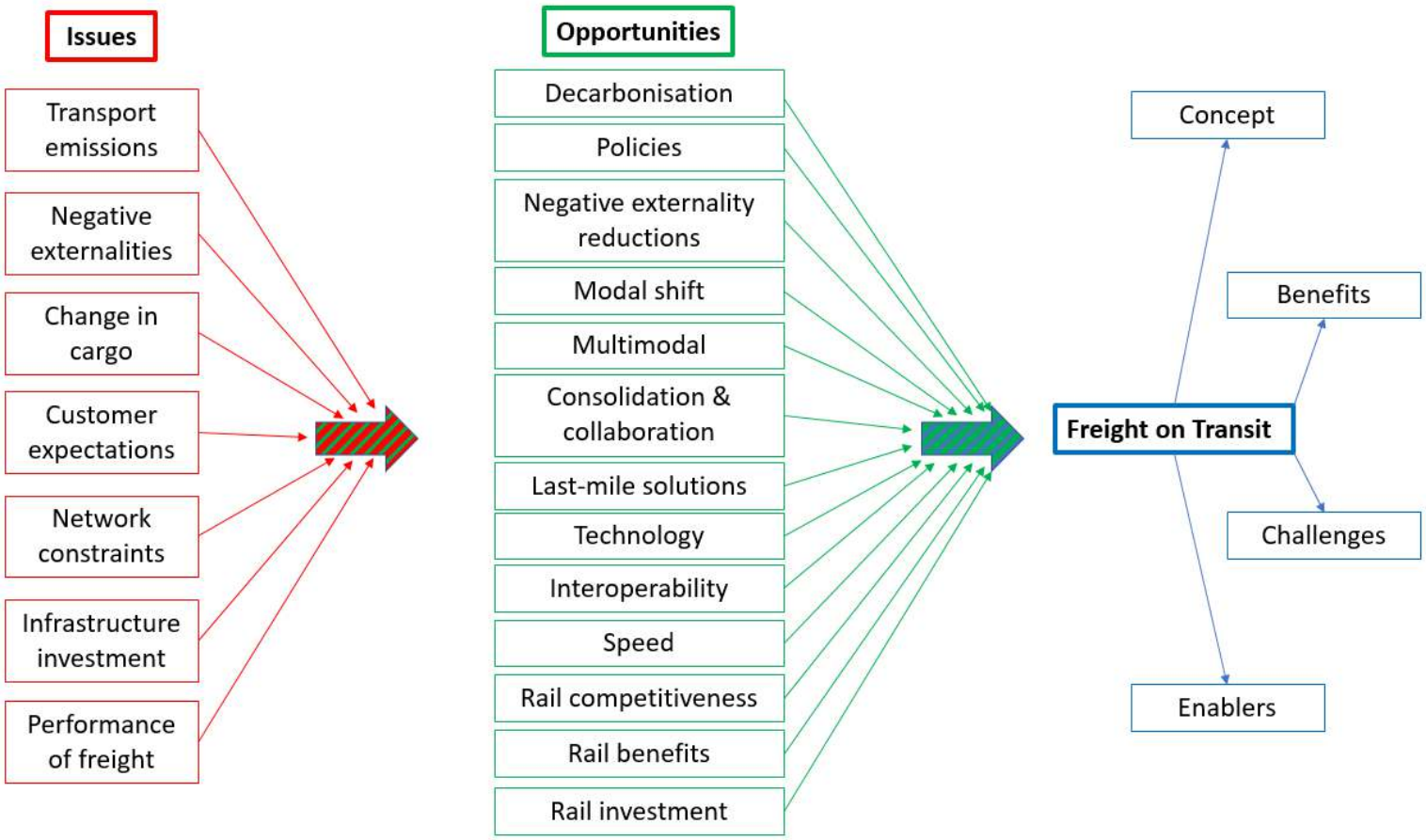
Conceptual literature has highlighted enablers for successful implementation of FOT. For example, FOT can be successful with collaboration (VanDuin *et al.,*2019; Cleophas *et al.,*2019; Sun *et al.,*2020) and technology advances (Agnieszka and Jagienka,2020). Conceptual studies note that one of the most feasible ways to utilise FOT is through underground freight transport (Hu *et al.,*2020b), to solve some of the issues freight faces (Hai *et al.,*2020) and to create sustainability (Cui and Nelson,2019; Hu *et al.,*2020a) through reduced emissions (Pan, Liang and Dong,2019). Underground infrastructure can be utilised for freight transportation to avoid and alleviate congestion (Pan, Liang and Dong,2019; VanDuin *et al.,*2019; Cui and Nelson,2019; Jiang *et al.,*2020; Hu *et al.,*2020a; Hai *et al.,*2020) and create a mass modal shift to rail (Hu *et al.,*2020b). Underground freight transport is also advantageous because it is not affected by weather, is efficient and has large capacity (Hai *et al.,*2020). Conceptual studies note that underground freight can be automated (Cui and Nelson,2019 Hu *et al.,*2020b) including to load and unload cargo (Fatnassi, Chaouachi and Klibi,2015; Hai *et al.,*2020). If goods are automatically loaded and unloaded, this will transform how goods are transported and increase market share (Bharadwaj,2020). However, underground transport is costly (Hu *et al.,*2020b; Hai *et al.,*2020) and there are many technological, planning and political challenges (Cui and Nelson,2019).

In summary, the literature explored above demonstrates the issues faced by the transport sector and opportunities to overcome these issues. One opportunity is the use of FOT, however, there are only a handful of studies which focus specifically on FOT and little descriptive understanding of FOT; most studies are conceptual. The management requirements of the efficient use of FOT is not well understood. Therefore, there is clear paucity of empirical studies that explore the characteristics of FOT to better enable the movements of LDHV goods into urban areas. This research study aims to fill this paucity in the following chapters.

Conceptual framework:

From the literature explored above, a conceptual framework has been developed to conceptualise what is known in the literature that is relevant to this research study.

Diagram 1:



Methodology:

Introduction:

This next chapter will demonstrate the methodology used to carry out this research. The research methodology is used to systematically solve the research problem (Achari,2014; Devi,2017). Research methods explains the techniques and methods used to conduct the research (Achari,2014), whereas research methodology is concerned not just with the methods used but also the reasoning behind the methods (Devi,2017), and also referred to as the science of understanding how research is undertaken (Achari,2014). The research design is the conceptual structure used to conduct a research study (Srivastava and Rego,2011).

Research philosophy and approach:

The research philosophy underpins the methodological choice, research strategy, and the data collection and analytical techniques (Saunders, Lewis and Thornhill,2019). Interpretivism is the philosophical perspective of this research study. This is an interpretivist research study as the researcher aims to take into account what is meaningful for participants (Edirishingha, 2012; Saunders, Lewis and Thornhill,2019). This approach is used to create interpretations and new, deeper understandings of social contexts of FOT through questioning multiple experts; unlike positivism which is more rigid (Edirishingha,2012). Positivism is also not suitable for this study as it attempts to discover facts or 'laws' which applies to all (Saunders, Lewis and Thornhill,2019); instead the aim of this study and other interpretivist studies is to generate patterns (Collis and Hussey,2014). However, there are different strands of interpretivism, this researcher is a phenomenologist as they are asking participants for their lived experiences and interpretations (Saunders, Lewis and Thornhill,2019).

Interpretivism takes a subjectivist perspective (Collis and Hussey,2014; Saunders, Lewis and Thornhill,2019) and the ontological, epistemological and axiological of subjectivism recognises that there are multiple realities (Collis and Hussey,2014; Saunders, Lewis and Thornhill,2019). Subjectivism is based on participants perceptions and actions (Collis and Hussey,2014; Saunders, Lewis and Thornhill,2019). Additionally, subjectivism assumes that perceptions and opinions which are collated through the qualitative data, in this case interviews and in-depth questionnaires, are considered as facts and it is then the responsibility of the researcher to understand the data to determine what are facts (Collis and Hussey,2014). This is supported by Saunders, Lewis and Thornhill (2019) who explains that in this approach the researcher must understand participants point of view, which can be challenging.

The theoretical paradigm is an umbrella term which captures the epistemology, ontological and methodological approach that a researcher is taking (Guba and Lincoln,2016). The theoretical approach to be undertaken in this study is an inductive approach. An inductive approach is used in studies which have an interpretivism philosophical approach (Collis and Hussey,2014), as explained above. An inductive approach is also used if the researcher identifies a gap in the literature (Gabriel,2013; Engel and Schutt,2014; Saunders, Lewis and Thornhill,2019), which in this study is the paucity of FOT characteristics. Inductive research is created through observing reality (Collis and Hussey,2014) and inductive research is able to identify multiple realities (Lincoln and Guba,1985). This research study aims to understand these experiences and realities of FOT through interviewing transport experts to fill the literature gap and contribute to practice. An inductive approach is also used commonly in qualitative research (Gabriel,2013; Hammersley,2013; Greenfield and Greener,2016) which is why it is suitable for this study. This approach is also suitable for this study because an inductive approach is used when wanting to create general conclusions (Bloor and Wood,2006) and when trying to understand why something is happening (Hammersley,2013, Saunders, Lewis and Thornhill,2019); rather than trying to test pre-defined hypotheses (Hammersley,2013). For studies using an inductive approach, there is usually a small sample of participants and qualitative data, unlike a deductive approach which usually uses a large numerical sample (Saunders,

Lewis and Thornhill,2019). Bloor and Wood (2006) and Greenfield and Greener (2016) also agree that qualitative research typically has a small sample size and in-depth data to understand phenomena from participants experiences.

Sample:

"All sampling is done with some purpose in mind" (Lincoln and Guba,1985,p.199) the researcher must decide prior to undertaking the research on a sample to ensure that participants will provide meaningful data (Emmel,2013). Data must be collected from relevant participants, otherwise there will be poor quality and invalid data (Namey and Trotter,2015), therefore experts with a lot of experience in passenger transport and freight distribution were chosen for this study. Sampling is targeted to find and engage specific experts (Namey and Trotter,2015), participants are selected based on their relevance to the research topic (Bell, Bryman and Harley,2019). Therefore, this study undertook a purposive sampling technique. The selection of participants is based on the researcher's judgement of who will be most useful to help better understand the benefits, issues and opportunities of FOT in practice and because these participants can either confirm or contrast theory (Bloor and Wood,2006). Researchers undertaking purposive sampling must thoroughly consider who to use in the sample to justify their strategy. The participants must be able to relate and understand the topic being investigated (Emmel,2013). In this case the researcher is purposely picking those who are regarded as experts within passenger transport and freight distribution due to their level of experience. However, these experts are from different areas within passenger transport and freight distribution to ensure that there is a range of experience and opinions. This is supported by Bell, Bryman and Harley (2019) who note that purposive sampling is used to ensure there is variety of participants. However, a limitation of this study is that although all had different experiences within passenger transport and freight distribution, most were from within the rail industry. Only two participants were not from the rail industry; one participant was a managing director for UK operations of a large parcel courier and one participant was a transport professor. For future research a wider representation is needed to understand wider perceptions. Thirteen experts from various areas within passenger transport and freight distribution were interviewed and 5 from an infrastructure manager participated in in-depth questionnaires. A summary of the participants is explained in the table below:

Table 1:

No.	Participant description
P1	Rail freight consultant & CILT rail freight forum member
P2	Regional manager for a rail freight representative body
P3	Policy and access manager for a train and freight operating company
P4	General Director for a rail freight representative body
P5	Managing Director for a train operating company
P6	Network capacity manager for a freight operating company
P7	Rail network manager for a freight operating company
P8	Transport Professor
P9	Rail freight consultant
P10	Managing director of UK operations for a large parcel courier
P11	Managing director for a rail high speed logistic company
P12	Director for a rail logistic company
P13	Head of business development for freight infrastructure
Q1	Employee of an infrastructure manager - strategy
Q2	Employee of an infrastructure manager - freight
Q3	Employee of an infrastructure manager - project management
Q4	Employee of an infrastructure manager - strategy
Q5	Employee of an infrastructure manager - freight

Purposive sampling is a form of non-probability sampling (Greenfield and Greener,2016; Bell, Bryman and Harley,2019). Non-probability samples select participants for specific reasons, in this study it is due to participants experience within passenger transport and freight distribution, rather than because of mathematical probability (Bloor and Wood,2006; Bell, Bryman and Harley,2019). Non-probability sampling is used for qualitative research like this study (Namey and Trotter,2015; Greenfield and Greener,2016). Probability sampling is also not used in this study because it is difficult to select random samples in qualitative research; especially when a researcher is aiming reach a wide range of relevant participants so that different perceptions are captured (Bell, Bryman and Harley,2019).

The aim of purposive sampling is to represent a population which can then be used to generalise a conclusion (Lincoln and Guba,1985). In this study the researcher aims to generalise the understanding of the characteristics of FOT from experts who have experience within passenger transport and freight distribution, to get a deeper understanding of the challenges, opportunities and benefits of FOT. Additionally, research which uses this type of sampling improves the generalisability of research findings, as the sample is likely to represent the population (Bloor, and Wood 2006). This type of sampling is popular within inductive (Bloor and Wood,2006; Emmel,2013; Greenfield and Greener,2016) and qualitative studies to explore meanings from various backgrounds (Namey and Trotter,2015); generalisations can be made through this type of research (Emmel,2013). Also, if there are deviant cases highlighted through the data, these can be used to explain why theory does not fit with reality (Bloor and Wood,2006).

Theoretical saturation was used as a sample parameter for this research study. Theoretical saturation is when data is collected until you no longer learn something new about the topic (Namey and Trotter,2015) and when additional data confirms previous theories and does not provide new insights (Bloor and Wood,2006). The researcher ceased gathering data once they felt that they had reached theoretical saturation; after 13 interviews and 5 in-depth questionnaires.

Data collection and analytics:

This research takes a qualitative approach. Qualitative research is described as “an approach that enables researcher to explore in detail social and organizational characteristics and individuals behaviours and their meanings” (Lapan, Quartaroli and Riemer,2011,p.69). Qualitative data collection and analysis are used for interpretivist studies, like this study (Atieno,2009; Collis and Hussey,2014), because qualitative methods are adaptable in understanding that there are multiple realities (Lincoln and Guba,1985). Qualitative research is used to create rich data through selecting knowledgeable participants (Namey and Trotter,2015), therefore experts within passenger transport and freight distribution were interviewed and questioned. Qualitative data helps to fill gaps and understand perceptions, behaviours and attitudes, which cannot be done through quantitative data (Namey and Trotter,2015), hence why qualitative data was collated because the aim of this study is to understand the paucity of FOT characteristics.

Most qualitative research is undertaken using interviews for the primary data collection (Lapan, Quartaroli and Riemer,2011; Namey and Trotter,2015). Interviews are versatile (Bell and Waters,2014; Namey and Trotter,2015) and can provide information whilst also generating understanding of experts perceptions, interpretations, opinions and experiences (Salmons,2014; Namey and Trotter,2015; Greenfield and Greener,2016); especially for a narrow topic, FOT in this case, that requires depth and for when independent responses are needed (Namey and Trotter,2015). Interviews allow immediate follow-up for clarification (Greenfield and Greener,2016), unlike questionnaires (Bell and Waters,2014). Individual in-depth interviews should be undertaken with those who have relevant experience (Lapan, Quartaroli and Riemer,2011); which is why those with years of experience were interviewed.

The interviews were semi-structured, base questions were pre-set, but other questions were allowed to be added (Tewksbury and Mustaine,2014). The participant is not expected to discuss much more than what is beyond the scope of the topic and the interviewer leads the interview (Lapan, Quartaroli and Riemer,2011).

Semi-structured interviews allow the researcher to gain responses which are summarised and that can be analysed, this is harder if undertaking an unstructured format (Bell and Waters,2014); therefore interviews followed a semi-structured format because the researcher is aiming to compare findings between participants and because structured interviews are too rigid (Corbetta,2003). An advantage of semi-structured interviews is that it allows the researcher to alter the questions during the interview (Tewksbury and Mustaine,2014), this allowed the researcher to add in additional questions for confirmation of understanding or to gain deeper understanding. Semi-structured interviews are one of the most popular types of qualitative data collection, which are excellent to gain in-depth accounts of experiences and thoughts (Sparkes and Smith,2016).

For the individual interviews, these were conducted over the phone or over a video call, this is due to the current coronavirus restrictions; fortunately, technology allows interviews to be conducted over the phone or internet (Greenfield and Greener,2016). This approach also allow interviews to be conducted with those who are geographically dispersed (Salmons,2014; Namey and Trotter,2015; Greenfield and Greener,2016), at any time (Salmons,2014), whilst also being cost effective (Namey and Trotter,2015; Greenfield and Greener,2016); this enabled the researcher to access a wider range of experts. Video calls also allow for interviews to be recorded (Namey and Trotter,2015), this was helpful as the interviews were replayed and transcribed, this allowed for statements to be checked and so that the researcher can keep eye contact with participants (Bell and Waters,2014). However, if interviews are recorded there is an issue about the interviewee being less open (Bell and Waters,2014; Greenfield and Greener,2016). To mitigate against this, all participants were told that they would be kept anonymous to ensure that they would be as open as possible. However, there are issues with online interviews, as it is harder to read body language (Namey and Trotter,2015; Greenfield and Greener,2016) and also harder to develop a rapport (Salmons,2014; Namey and Trotter,2015); especially if the researcher and participants have not met prior to the interview (Namey and Trotter,2015). The interviewer should ask questions in a way in which encourages respondents to share experiences and thoughts (Green and Thorogood,2009). Interviewers must be empathetic, respectful and use thoughtful questioning and listening (Salmons,2014). However, interviewing is difficult and requires a skilful interviewer to probe responses and investigate opinions and feelings, unlike a questionnaire (Bell and Waters, 2014). Additionally, success of interviews depends on the researchers' skills and the presence of the researcher may affect the data collected (Greenfield and Greener,2016). Therefore, to avoid the influence of the researcher, in-depth questionnaires were also used in this study.

Utilising multiple data collection approaches helps the researcher to obtain perception, understandings and meanings (Lapan, Quartaroli and Riemer,2011). Qualitative data was also collected through online, in-depth questionnaires; a recognised approach of collating qualitative data through using open-ended questions (Hammersley,2013). Authors note that questionnaires should use as few open questions as possible (Greenfield and Greener,2016), however, these questionnaires used open questions to gather qualitative, in-depth data in a way which is away from the researcher and in an anonymised fashion so that participants are open and honest. This was facilitated by online questionnaires, because the way questionnaires are administered affects how participants respond (Greenfield and Greener,2016). The same, open-ended questions (which can be found in Appendix 1) were asked in both the interviews and questionnaires, because question wording is just as important in both interviews and questionnaires (Bell and Waters,2014). Open ended questions are used in qualitative research as they are best to capture complexity (Lapan, Quartaroli and Riemer,2011).

All interviews were recorded so that they could be transcribed and coded (Bell and Waters,2014). Once the interviews and questionnaires were completed, they were transcribed so that the data could be analysed. The process of transcription is time consuming (Bell and Waters,2014) because interviews generate a lot of data. The interviews undertaken in this research amounted to 10 hours of interview time. This data then needed to be summarised, through coding (Greenfield and Greener,2016). The transcripts from the interviews and data from questionnaires were collated and thematic analysis (TA) was applied to generate

codes (Namey and Trotter,2015). TA is a method of qualitative data analysis (Braun and Clarke,2013) and one of the most popular methods (Sparkes and Smith,2016; Willing and Rogers,2017), yet not always acknowledged as an analysis method (Braun and Clarke,2006; Braun and Clarke,2013). TA is used to "identify patterns of meaning across a qualitative dataset" (Sparkes and Smith,2016, p.191); supported by Bryman (2012). The process of TA has seven steps: transcription; reading and familiarisation (noting items of interest); coding across all data; search for themes; review of themes; definition and naming of themes and the final analysis (Braun and Clarke,2013). During this TA process, initially 600 codes were noted, before then being summarised into nine themes which were then defined and written up into the findings. TA is used because it is flexible (Braun and Clarke,2013; Willing and Rogers,2017) and able to analyse multiple types of qualitative data (Willing and Rogers,2017); this is appropriate for this study which is using both interviews and questionnaires. TA focuses on patterns across datasets; therefore, a disadvantage is that it does not provide agreements or disagreements within individual data sets (Braun and Clarke,2013).

Rigour and validity:

The rigour of research is to ensure legitimacy or soundness of research and results (Flynn and Kramer,2019). Rigour and quality of research is dependent on the researcher and requires reflexivity as well as the ability to decide on what is the best thing to do (Mauthner *et al.,*2002). Validity of research is the accuracy and strength of a research design; of which there are two basic types, internal and external validity. Internal validity allows the researcher to test the research hypothesis (Srivastava and Rego,2011). External validity on the other hand is the generalisability that conclusions apply to other situations (Bloor and Wood,2006; Srivastava and Rego,2011; Greenfield and Greener,2016). Experts within the same industry often agree with each other and give explanation when there is variability in experiences and opinions. Therefore, when a purposive sample is used, this data set is seen as being qualitatively valid, reliable and able to be used for generalisability, even with a relatively small sample (Namey and Trotter,2015). Reliability and validity can be improved through using various processes to collate qualitative data (Greenfield and Greener,2016), hence why both interviews and questionnaires were used in this study. There is the risk of bias when undertaking interviews (Bell and Waters,2014), this is why this research undertook both interviews and questionnaires, because the removal of the interviewer in questionnaires can remove bias. Therefore, this supports why this study undertook more than one type of qualitative data collection.

Triangulation is the "process of checking if different data sources and different methods allow you to reach the same conclusion" (Greenfield and Greener,2016, p.10). Both in-depth interviews and questionnaires were used to allow the researcher to compare findings for convergence and triangulation to validate findings (Guest *et al.,*2013). Triangulation techniques, in this case the use of more than one type of qualitative data gathering, can be used (Bell and Waters,2014) to "improve soundness of emerging conclusions" (Greenfield and Greener,2016, p.229).

Transcription also enhances validity because it provides a verbatim account (Guest *et al.,*2013; Namey and Trotter,2015). If transcriptions are made available this reduces scrutiny, because if there are no transcripts, there is a fear that researchers could make up quotations (Bell and Waters,2014); the transcripts for this research are not in the appendix as some information was commercially sensitive, and for ethical reasons because transcripts would reveal the identity of participants, however, these can be made available upon request where personal and commercial information will be removed. Verbatim quotes will be used in the findings and discussion to improve validity, so that the researchers interpretations are directly connected with what participants said (Guest *et al.,*2013).

Ethics:

This research study uses the University of South Wales' research code of conduct throughout (USW,2021b). This ensured that the research was of good quality, had rigour and that participants were not harmed and kept confidential in their participation of this research study.

Ethics concerns the moral behaviour within research (Mauthner *et al.,*2002; Wiles, 2012); the concern of ethics has increased over recent years (Mauthner *et al.,*2002; Wiles, 2012). Consent needs to be taken prior to an interview (Bell and Waters,2014), however, just taking a consent form does not make a study ethical (Mauthner *et al.,*2002), other ethical issues must be addressed throughout the research (Mauthner *et al.,*2002; Wiles,2012). Informed consent is important (Wiles,2012; Bell and Waters,2014), therefore, prior to interviews the participants were sent information about the study, what the study entails and a consent form (Appendix 2). Participants were informed of some details of the study, but not fully informed as that may influence answers (Wiles,2012). For example, in this study the participants were told of the wider topic of moving LDHV goods into urban areas, but not specifically about FOT. The researcher wanted to understand whether experts would come up with FOT as a solution for moving LDHV goods into urban areas before being asked specifically about it, and because the researcher did not want participants researching FOT prior to the data collection. All interviewees were asked for their permission at the start of the interview to record the interview so that they could be transcribed, however, the interviewee makes the decision as to whether the interview can be recorded or not (Greenfield and Greener,2016). Other ethical protocols include the researcher explaining to participants that they are free to withdraw at anytime, and that they do not have to answer questions that they are uncomfortable with (Bell and Waters,2014), this was stated in the consent form for the interviews and at the start of both the interviews and in-depth questionnaires.

Ethical research challenges include privacy, anonymity, confidentiality and informed consent. Confidentiality and anonymity are very important within ethical research and anonymity is key to protect participants (Wiles,2012). To ensure this, the researcher stated in the interview and questionnaire invites, and also at the start of the data collection process that participants will be kept anonymous throughout, and data will be kept confidential on a locked computer; this was also to encourage honesty. However, for research that is undertaken online, there are additional ethical challenges which need to be taken into consideration. The researchers must be content that gaining consent remotely is sufficient (Pope and Mays, 2020). For interviews, because they were not face-to-face and therefore unable to physically sign the consent forms, participants were asked to either fill in the consent form digitally, or provide an email with confirmation that they had read all the information in the information sheet and were happy to consent. Also, doing qualitative research online can be difficult to ensure the identity of the participant (Pope and Mays, 2020); however, because purposive sampling was used in this study, all participants were chosen in an attempt to eliminate this issue.

Findings:

Introduction:

This chapter will demonstrate the data that was found during the interviews and questionnaires from experts within passenger transport and freight distribution. During the data collection participants noted that the movement of LDHV into urban areas is a challenge due to the increase in LDHV good movements and increasing expectations of customers for a quick, sustainable and reliable service. However, an opportunity to combat these challenges is the use of FOT on rail, which was mentioned by all participants as a suggestion for better moving LDHV goods into urban areas, however only one interviewee was aware of the term FOT. All participants understood the concept of FOT, but the term is not well understood. Therefore, this research found that there are two classifications of FOT, the first is express logistics (EL) which is a freight train with passenger train characteristics and the second classification is freight on passenger services (FOPS) where freight is carried alongside passengers on passengers on services. These FOT services can be on rail, including heavy rail and light rail, or even buses, however, for the remainder of this research study, FOT will be in the context of FOT on rail.

This remainder of this chapter will focus on three main themes that have been highlighted through this research; benefits of FOT, issues of FOT and the opportunities for FOT.

Benefits of FOT:

The first sub-theme within the benefits of FOT is speed; “speed of delivery that passenger trains can give” (P4). This benefit was highlighted in the data by most participants, as FOT using rail has a speed advantage over other modes. FOT consignments can travel 100mph or more as soon as they leave a station or terminal and “average speed end to end is 70mph try doing that anywhere else with any other mode” (P12). Experts noted that FOT uses trains which have higher speeds than conventional freight trains, therefore FOT is “slightly less of a barrier for this higher speed stuff because for sure it is easier to path” (P13). Some participants noted that this benefits retailers and couriers as cut off times for next day deliveries can be later “because rail can offer that shorter end to end transit time and that then enables these parcel couriers to not have a cut off… they can push it back” (P11). This is important because a large parcel courier stated that “the real constraint around that is the time you have to cut off these services” (P10). Participants also noted that this is important for goods which are perishable, including medical supplies. EL operators noted that “journey times we have set compared to road … we reckon we can do it in about half the time” (P3). Also, it was found that often the rail network mirrors the major road networks with quicker journey times, therefore there is an opportunity to address the courier-to-courier market of trunking by rail between cities, and an opportunity to move goods from a distribution hub to a station in an urban centre. Additionally, it was stated that because FOT has the characteristics of passenger trains they are flexible and able to operate on most routes, their size and abilities allow them to operate on multiple traction modes.

Another key benefit and another sub-theme are the societal benefits of FOT; “societal benefits are all of the stuff I have talked about so road congestion and environment” (P9). A main societal benefit is that if more LDHV goods are moved by FOT, there will be an improvement in the level of road accidents and congestion. Most participants noted that another societal advantage is the environmental benefits, including improved air quality. Participants agreed that a more sustainable solution is needed to move the increasing amount of LDHV goods, an operator of EL noted “decarbonization has really gained momentum it has moved up the agenda now with a lot of these companies and that is just playing fantastically into our hands” (P11). The data found that rail can save hugely on carbon emissions when compared to equivalent road journeys; especially “if you use an electric train then there is virtually zero emissions” (P12). Yet, noise pollution was mentioned by some participation, however, if FOT is operating on electrified routes, these are quiet. Some participants also noted that “one of the great benefits of rail freight is abrasive emissions are very very low”

(P9) when compared to road vehicles, as these are produced by the brakes and tyres. Additionally, one participant mentioned that rail lines are mostly segregated from people which means that people are shielded from emissions. However, although "people want to do the right thing environmentally it has to make sense financially" (P3) to create a shift to FOT.

The data also highlighted that there are increasing policies being implemented in urban areas, mainly due to the focus on decarbonisation. Restrictions are mainly on road vehicles in urban areas, a large parcel courier noted "more and more we are being restricted" (P10); such policies include ultra-low emission zones and congestion charging. These restrictions are increasing the cost to road freight, which benefits FOT; a FOPS operator explained that "the increasing challenges of doing it by road are such that rail is coming back into the contention" (P12). Road congestion was mentioned by most participants as an issue within freight transportation. However, FOT is not constrained by road congestion, "by moving it on rail you are saving on road congestion" (P2), this is beneficial because participants noted that congestion makes road journey times longer, unpredictable and more expensive. Yet, in comparison, many participants noted that rail has a high journey time reliability, and that "journey time reliability by rail is greater than by road" (P9), which is important to customers.

A final benefit noted by many participants is that FOT is not complicated. A FOPS operator noted that FOT is a "very simple way of offering it to the marketplace with very little risk" (P5); "a bag of parcels on a seat is about as sophisticated as it needs to be" (P4). Also, it was mentioned that this concept is not new "this type of operation has been used successfully in the past in the UK and abroad" (Q1). Passenger operators already move things on and off trains such as catering trollies and wheelchairs, and stations have barriers wide enough for goods. However, there is some reluctance from passenger operators to test this out, they perceive FOPS as "as a distraction … all a bit too difficult" (P6), even though experts noted that FOPS is profitable for passenger operators. However, it is not just buy-in from train operators, there needs to be buy-in from infrastructure managers and governments, they require guidance about how these services are operated and how they are governed.

Challenges of FOT:

The next theme is the challenges of FOT and the first sub-theme within this is middle and last mile distribution challenges; FOT cannot "do the whole end to end delivery such as last mile to customers' homes" (P4). Participants agreed that FOT is best at completing the long-distance trunking and for bulk movements, but many participants note that there needs to be access from a station to other modes for the last mile distribution. For the last mile, road was noted as the dominant mode of choice; one reason why road is dominant over FOT is because FOT is less flexible than road freight and it is more difficult to locate rail vehicles when there is an issue. This is important because "the retailers they are risk adverse" (P9), this is supported by the participant who is a managing director for UK operations of a large parcel courier who states that "we are risk adverse" (P10). Participants agreed that governments and infrastructure providers need to encourage a modal shift from road to FOT by having a smooth transition between FOT and last mile distribution. There needs to be sustainable facilities and other investments and incentives, so that retailers and freight distributors can take advantage of the benefits of FOT mentioned above. All participants noted examples of modes which can be used to link FOT to the end customer which are sustainable. These included cargo bikes, electric vehicles (EVs) and drones. Cargo bikes were mentioned by most of participants, these are becoming popular due to their agility, relatively low investment and because they are "quicker than the equivalent road vehicles could but again they are restricted by payload capabilities and range" (P12). EVs were also noted by most participants to move LDHV goods to end customers in a sustainable way. EVs have improved over recent years, yet they still emit abrasive emissions from tyres and brakes and susceptible to limited ranges and "if road congestion continues they're still going to be delayed" (P5). Drones were also mentioned by many participants as an option to support FOT but noted that "there is vandalism" (P7) and not good in areas where there are lots of people, like urban areas.

Cargo bikes, EVs and drones all have limited ranges, therefore participants noted that FOT hubs need to be located near to the end customer, including at stations; “none of this is reinventing what railways used to do using stations as urban freight interchanges” (P12), stations today be used as multipurpose areas.

Another challenge noted by most participants is the perception issues of FOT. There is evidence that rail has a high journey time reliability, however, there needs to be confidence from potential users that FOT can “deliver reliably … it is a perception thing” (P6). There are also perception issues from the infrastructure operator and passenger operators that FOT will cause performance issues, “freight back onto passenger services could only mean chaos and disaster and reliability” (P12), but a participant who operates FOT stated that this is not the case. Another fear is of disruption of vehicles, yet there are diversionary routes, although, diversionary routes “significantly slows you down so you lose that benefit of time” (P3). Potential FOT customers need convincing their services won’t suddenly be disrupted or taken away and that there is a clear plan when there is disruption; a FOT company “has a model for this” (P4). There is also a perception that FOT should only run at night, it is agree that FOT should run outside of the peak hours, but “to be economic you need to use the resources a lot which means that you can't just run overnight … you have to have intensive utilisation” (P9). Similarly, cost is also a perception issue for FOT, because FOT can be cheaper and profitable, especially if goods are being moved on existing passenger services, passenger operators who operate FOPS note that “there is no real cost to us” (P5). However, there is still investment required in infrastructure like wagons, warehouses and facilities for loading and unloading of goods “what you need really is sophisticated receiving and loading into trains” (P2). There is also the cost of the staff and risk of facilitating these good movements. However, experts note that these are not the responsibility of the passenger operators but of specific, experienced FOT companies. These companies need to be well organised so that there are no delays and to ensure that trains do not dwell in platforms for longer than their specified times; however, participants from FOT companies have proven that FOT is efficient and does not cause delays; “reliability is 97%” (P12).

Capacity is another barrier and sub-theme mentioned by participants. Many note that the due to the increase in services, “the network has become more congested” (P2) and therefore network capacity is an issue, making it more difficult to find paths for EL, but there is an opportunity to use these frequent services for FOPS. There is also inflexibility within timetables, as passenger operators are often unwilling to move their trains to enable an EL train to leave. There needs to be flexibility and not too many restrictions, or “loosening of the rules” (P11) on EL services to encourage modal shift. Capacity of the trains is also an issue because if LDHV goods need to be containerised the perception from couriers is that this reduces the capacity of goods you can get onto a train; “capacity for us is a huge benefit if we put it on the road”(P10). Also, with regards to train capacity, if goods travel through FOPS, there is no “guarantee of capacity unless you have a specific reserved space” (P3) or a dedicated EL train. Other capacity issues include issues at platforms and terminals to manage the loading and unloading of FOT, path access to them and availability of platforms and terminals. Some experts noted that more investment is needed for additional platforms and terminals, and to make existing ones more efficient, with increased access. One participant mentioned that “a dedicated parcel platform is no longer there” (P11), however, if stations are again going to be used as multipurpose areas, there needs to be segregation from passengers. Additionally, it is not just the capacity of the platforms and terminals, “you need road access” (P1) for connecting distribution activities, which was noted by most participants.

Security is another issue and sub-theme, which was mentioned by most participants. There are “security concerns potentially depending on what it is you're moving whether it actually fits with being on a public train that has the general public travelling on it” (P6); and the issue of the “responsibility for dangerous goods” (P7). Other issues include the security of the goods as some mention that goods could be susceptible to being taken by passengers or risk of goods being damaged; “you couldn’t mix parcels and passengers unless you have secure areas” (P10), to combat this, participants explained that goods can be locked in a separate carriage.

FOT opportunities:

The first sub-theme is the reduction of passengers and passenger services due to the coronavirus pandemic. This is creating an opportunity for FOT because a "drop in passengers frees up capacity for light freight movements" (P2). If fewer passengers and passenger services continues after the pandemic, many noted that this can free up capacity for more EL services, rather than investing in creating more capacity on rail. Some experts have found that the reduction in passenger numbers has created a "growing interest in it" (P4), because FOT is "an additional incremental revenue stream for the passenger operators" (P13). Also, "passenger train services have under-utilised space, particularly post COVID, and there must be opportunities to exploit this" (Q1), but participants noted that even before the pandemic there was capacity on trains outside of the peak hours; therefore, there are opportunities to use under-utilised space on trains and to improve efficiency and utilisation of these vehicles and infrastructure. Also, the reduction in passengers and economic impacts due to coronavirus has meant that train stations have "increasingly empty retail units" (P4) which can be used as an opportunity for storing goods for FOT, this was supported by other participants.

Another opportunity mentioned by participants is to either lock out a separate carriage, or "put another freight train on the back" (P12) of existing passenger services. However, many agreed that for cargo hitching, the "ability to just hitch something that may be more difficult than historically it used to be but not necessarily impossible" (P6). Therefore, another option is to use the guard van spaces on rolling stock; however, many agreed that "the guards van which we don't have anymore on modern trains" (P8). There can be a trade-off between seats and space for FOPS, but "they will need to redesign their vehicles and go back to having vans or largish luggage spaces" (P7). This can be difficult, especially if improvements like bigger doors are needed, and this requires investment. A final opportunity is repurposing old passenger trains for EL, because "there is a large amount of rolling stock that they cannot export that that they cannot repurpose for anything else" (P12).

There is an opportunity to use existing networks in cities which has comprehensive urban rail networks. FOT can transfer goods from one part of the city to another in an efficient and cost-effective way. These existing networks are fast and have very frequent services, especially during peak times, FOT is "quicker and cheaper than driving in peak times in cities" (P3). There is also an opportunity because "a moving transit vehicle going into destinations all over the country linked already in a network that exists" (P4). These movements are to all major urban centres, "our stations are often in exactly the right places in the centre of the major urban centre" (P13) and even to lesser urban centres, meaning that FOT can also be used for rural areas. This is therefore an opportunity to use underutilised space because "the thing is running anyway so it is taken advantage of an opportunity without being solid with high fixed costs" (P6) and using an existing service means "therefore you are not adding to energy consumption and environmental degradation" (P2).

FOT allows new customers to access rail because FOPS can move small consignments quickly because they don't have to "wait until you have a full train load before the train leaves the origin" (P12). Also "the end customer does not need to fill a whole train meaning it could reach a wider market" (Q3). Fulfilment sizes can include single parcels or roll cages which can be easily moved on and off trains. Also, if EL is used, there is an opportunity to "run a 12 car train that is split at an intermediate point" (P3) to serve different areas that that wouldn't necessarily have the volumes to justify a full train. This can help to encourage a shift from road and help smaller firms access an environmentally friendly and fast mode, through using FOT.

Table 2:

Examples of additional supporting quotations from participants:

Sub-theme:	Participant:	Example quote to support theme:
Speed	P3	“speed you have another selling point too”
Speed	P1	“the speed of rail can be advantageous”
Societal benefits	Q3	“This would have carbon/road congestion benefits”
Societal benefits	Q4	“scale of economy and carbon savings”
Road restrictions	P10	“a lot of urban areas have restrictions”
Road restrictions	P11	“congestion but it is also low emission zone charges … clean air zones”
Ease of FOT	P6	“going back to how the railways used to operate”
End to end supply chain	P1	“rail cannot be the whole answer if you look at supply chains rails role is clearly in the trunk and leg”
End to end supply chain	Q2	“you could set up local hubs close to train stations so the end delivery could still happen via Van/Car/ Motorbike/Scooter”
Perception	P12	“reliability is around 97% within 15 minutes of schedule”
Perception	P8	“People have to be convinced that the trains will actually get there”
Perception	P3	“that there is not a risk of the service suddenly being disrupted or taken away”
Capacity	P9	“big issue is terminal's there is absolute lack of appropriate places”
Capacity	P13	“our network is full of empty coaching stock movements even before covid … Metro frequency service for in most of these places it completely congested and clogs up the railway”
Capacity	Q5	“Equally pre-covid there was a scare capacity on the rail network into urban centres especially in peak times”
Security	Q3	“Security e.g. would it bring unknown/dangerous items”
Reduction in passengers	Q1	“Many bus and passenger train services have under-utilised space, particularly post covid”
Reduction in passengers	P6	“provisions on passenger services today there is a lot of off peak capacity and there is also hidden capacity … HSTs has a huge guards van at each end which might carry the old bike but that space is not really being used”
Cargo carrying	P5	“we could add another vehicle that was converted from a passenger vehicle in the train just to carry this freight”
Cargo carrying	P2	“there is a trade off again between seats and accommodation for these goods”
Existing network	Q5	“Transport could also take place on passenger trains between city centres or from a station near a distribution hub to an urban station”
Cargo volumes	P3	“split off into three different services and run off to smaller locations The benefit of that is you can potentially serve markets that traditionally would not have used rail because the volumes weren't Big enough so they would never see an intermodal train”

Discussion:

Introduction:

This chapter will be used to compare the findings of this research against what is known in the literature as summarised in the conceptual framework, Diagram 1. This chapter will explain where there is consensus or divergence between what has been found in the primary data and the literature. The second part of this discussion will discuss the contribution to theory and practice.

Benefits of FOT:

Benefits of FOT is the first theme to be explored within this discussion; the first sub-theme is speed. Both the literature (Zhang and Schramm,2020) and participants (P6; P12) agree that there is a growing demand for goods to move faster and that FOT is best at moving time sensitive goods (P5; P6; P13; Zhao *et al.,*2018; Singh and Gupta,2020). There is an opportunity for FOT because rail is able to move goods at a high speed, FOT "can be doing 100 mph within a mile of leaving a station" (P12). Speed benefits were mentioned throughout the findings (P1; P3; P4; P5; P9; P12; P13), and by many in the literature (Myronenko and Hrushevska,2018; Yu *et al,.*2018; Beskovnik and Golnar,2020; Bharadwaj,2020). Participants expanded on this further to explain that FOT takes about half the time compared to road (P3; P11), and the faster goods move, the faster the return on investment (P3; Bharadwaj,2020). Due to FOT operating under passenger train characteristics, experts noted that these are easier to path due to their speed and flexibility compared to traditional rail freight (P3; P13); literature agrees because it is noted that if freight vehicles match the characterises of passenger trains, they can be better integrated (Zunder and Islam,2018). The other benefits of higher speed meant that couriers and retailers can have later cut off times, this was mentioned by participants (P10; P11), "rail can offer that shorter end to end transit time and that then enables these parcel couriers to not have a cut off … they can push it back" (P11); this was not addressed in the literature. Similarly, another contribution from the findings is a "colossal opportunity for addressing the courier-to-courier market … many do not have their own trunk networks they have to trade with some of the bigger players who are their competitors". FOT facilitates the trunking between cities (P1; P2; P3; P6; P12; Q1), often rail lines mirror motorways (P3) and there are existing services between cities which can be utilised (P4; P5; Q5).

The next benefit is the societal benefits of FOT which was referenced in this research and literature (P9; Cochrane *et al.,*2017; DeLanghe *et al.,*2019). However, participants further explained that FOT cannot rely on societal benefits alone (P3; P9), because "as much as people want to do the right thing environmentally it has to make sense financially" (P3). The findings and literature agree that specific societal benefits include the reduction in negative externalities (P9; Woodburn,2017; Behiri, Belmokhtar-Berraf and Chu,2018; Hu *et al.,*2020b; Singh and Gupta,2020; Jiang *et al.,*2020; Bruzzone, Cavallaro and Nocera,2021), such as fewer road accidents (P12; Bozejko,2017; Chen *et al.,*2017; Ozturk and Patrick,2018) and congestion (P2; P3; P11; P9; Q3; Bozejko,2017; Ozturk and Patrick,2018). Literature states that there is little congestion for FOT (Bozejko,2017), however, experts disagree and noted "the network has become more congested" (P2) and that network capacity is an issue (P6; P9; P13; Q5). Another societal benefit from FOT is the reduction in carbon emissions (P3; P6; P9; P11; P13; Q1; Q5; Zhao *et al.,*2018; DeLanghe *et al.,*2019; VanDuin *et al.,*2019; Hu *et al.,*2020b; Heinold, 2020), an expert operating EL services stated that "decarbonization has really gained momentum it has moved up the agenda now with a lot of these companies and that is just playing fantastically into our hands" (P11). Experts noted that there is a huge carbon saving for FOT compared to road, especially when operating on electrified routes (P11; P12) because "an electric train has virtually zero emissions" (P12); this is supported by the literature (Woodburn,2017; Kaack *et al.,*2018; Fan *et al.,*2019). Participants also noted that if FOT uses electric traction, which reduces noise pollution (P13), this was not noted in the literature.

Restrictions and constraints for road vehicles is another benefit of FOT, noted by many participants (P3; P5; P9; P10; P12; Q2). An expert who is a director for a large courier noted that "more and more now we are being restricted on emissions for emission levels in cities" (P10) and another participant stated that "lorries are priced off the road network" (P9). These policies which are causing restrictions include congestion charging (P3; P9; Canitez,2020) and ultra-low emission zones (P3; P9). The literature states that policies are used to restrict vehicles in cities and to encourage a modal shift to rail and FOT (Kaack *et al.,*2018; Bektas *et al.,*2019; Li and Zhang,2020a; Li and Zhang,2020b; Esposito, Cicatiello and Ercolano,2020; Canitez,2020; Cuppi *et al.,*2021). Additionally, primary findings and literature agrees that FOT can be used to reduce congestion (P3; P2; P9; P11; Q3; Q5; Bozejko,2017; Ozturk and Patrick,2018; Yu *et al.,*2018; DeLanghe *et al.,*2019; Singh and Gupta,2020; Jiang *et al.,*2020). Experts and authors also agree that congestion is an issue because it delays road transport (Sun *et al.,*2018; P3; P5; P10; Q5) and that the "road network becomes more unstable because it has more traffic on it" (P12). These issues make rail a quicker and more attractive alternative to road (Newman,2020; P3; P4; P5; P6; P11; P12; Q3).

Many participants agreed that FOT is not complicated (P4; P13), as it is not a new concept (P2; P5; P6; P8; P10; P12; P13; Q1; Q2). Also, today "on the intercity trains you have people putting trolleys on and goods coming off and bags of waste coming off it is no different it is exactly the same … it is not too difficult" (P13). However, the literature disagrees as it perceives that FOT is complex due to many challenges (Mazzarino and Rubini,2019; Nocera, Pungillo and Bruzzone,2020; Sun *et al.,*2020), and so does an expert from a large parcel couriers, who believes that FOT is complicated because it adds "further complexity" (P10). These perceived challenges means that "there is a reluctance for anybody apart from potentially an Open Access operator to test that market" (P5) and that operators "see it as a distraction" (P6), when actually passenger operators get revenue from it and do not need to get involved, it is all managed by a FOT company (P12).

Challenges of FOT:

A key challenge of FOT is perception. There is a perception that FOT is unreliable and will cause performance issues (P4; Q3), however this is not the case which is clearly demonstrated by a participant from a FOPS company who stated that "reliability is around 97%" (P12). Authors support this perception issue and stated that public transport networks are perceived as being slow, unreliable, and inflexible (Bruzzone, Cavallaro and Nocera,2021), yet other authors disagree and note that FOT can improve reliability (Hu *et al.,*2020b). This perception of unreliability may be due to both participants and literature agreeing that FOT is less flexible than road (P6; P10; Muller, Rudolph and Janke,2019), especially when there are disruptions (P3; P6; P8; Q3). Yet participants argue that FOT vehicles, because they have the characteristics of a passenger vehicles "there aren't many places that they can't go" (P3) and there are diversionary routes, although these are often slower (P3); this is not the discussed in the literature. Additionally, one participant who operates FOPS also stated that another perception is that "it's going to be expensive or it's not going to earn them much money and it's going to cost them in manpower but none of that applies" (P12). This is a perception issue because participants agree that FOT is cost effective in practice (P6; P9; P12) and "an additional revenue stream for the passenger operators" (P13); supported by other participants (P5; P12). Multiple authors agree that FOT is economic (Behiri, Belmokhtar-Berraf and Chu,2018; Watson, Ali and Bayyati,2019; Liang and Tan,2019; Bushev, Shulman and Sagajdak,2019) through reducing costs (Jiang *et al.,*2020; Fatnassi, Chaouachi and Klibi,2015; Cochrane *et al.,*2017; Standing, Standing and Biermann,2019; Jiang *et al.,*2020). However, one interviewee noted that FOT is only "profitable if done right" (P5), this is supported by literature which found that economic feasibility depends on the amount of cost savings (Amaral *et al.,*2018). Although profitable, FOT has the perception that it is not it is not economic because investment is required (Cochrane *et al.,*2017; P9; Q2; Q3; Q4), such as the redesigning of rolling stock (P7) because "if you have to convert passenger vehicles that is a big number" (P9). Therefore, "greater government encouragement/incentives for users" (Q1) is needed, supported by the literature (Sun *et al.,*2020), however, investment must have political will (Mazzarino and Rubini,2019;

Nocera, Pungillo and Bruzzone,2020). The findings also demonstrated that investment is required for equipment to for loading and unloading goods (P1; P2; P6; P8) and the cost of staff to facilitate this (P5; P7; P8); these activities also take time (P6) and are a risk to staff (P10). Although these thoughts are not shared in the literature, the literature does mention that if goods are automatically loaded and unloaded for FOT, this will transform how goods are transported and increase market share (Bharadwaj,2020).

Capacity is another challenge of FOT highlighted in this research. Many experts (P6; P9; Q5) agree that "network capacity is a big issue" (P9); the rail network is congested (P2; P13). Experts state that the rail network is congested because Metro frequencies "clogs up the railway" (P13) and congestion makes it difficult to find paths for an EL service (P3). Yet, literature believes there is no congestion for FOT (Bozejko,2017) and that there is underutilised capacity on rail systems (Zhao *et al.,*2018; DeLanghe *et al.,*2019; VanDuin *et al.,*2019; Jiang *et al.,*2020). However, participants agree that although there may not be spare capacity on networks, there is spare capacity on trains outside of peak hours (P1; P4; P5; P6; P12; P13); authors agreed with participants that goods can be moved through exploiting underutilised passenger trains for resource optimisation (Cochrane *et al.,*2017; Behiri, Belmokhtar-Berraf and Chu,2018; Zhao *et al.,*2018; DeLanghe *et al.,*2019; VanDuin *et al.,*2019; Jiang *et al.,*2020). Experts also agreed that resource optimisation is needed (P1; P2; P9; P12; Q3; Q4) resource optimisation means the movement of goods using FOT is "not adding to energy consumption and environmental degradation" (P2). However, participants (P1; P4; P6) note that FOT should be used outside of peaks; "move fast freight between the peaks" (P1). Literature supports that freight should only be carried in the off-peaks (Fatnassi, Chaouachi and Klibi,2015; Zhao *et al.,*2018; DeLanghe *et al.,*2019; Sun *et al.,*2020), so that passengers aren't disrupted (Cochrane *et al.,*2017; Massson *et al.,*2017). However, other capacity issues noted in the findings include at stations, including platforms for loading and unloading goods (P7; P9; P13; Q3; Q5); "passenger termini which are already short of space" (P7). Literature does not discuss capacity use or constraints at stations; therefore, this is a contribution and an area that can be studied further.

Security is the final sub-theme for FOT challenges; mentioned by most participants (P3; P4; P6; P7; P8; P10; P12; P13; Q3). Participants also note that some goods may be dangerous to carry on a public train (P6; Q3) and then there is a liability issue (P7; P10). Participants also noted that goods could be susceptible to being taken by passengers (P8; P10; P13) or risk of goods being damaged (Q3). Some literature agrees that there are issues when combining freight and passenger (Myronenko and Hrushevska,2018). Yet, these issues can be solved because participants mentioned that FOPS has run in the past (P7; P13) and that in practice this is not an issue, a FOPS operator noted that there is a "mindset that carrying parcels is somehow going to be a security threat" (P12). To combat this, participants noted that goods can be carried in a separate carriage (P5; P10; P12; P13), and in practice, "you just lock the carriage out" (P13), the use of separate carriages is supported by the literature (Cochrane *et al.,*2017; Liang and Tan,2019; DeLanghe *et al.,*2019), but not specifically for security reasons.

Opportunities of FOT:

The first opportunity found in this research is the use of existing networks, as they enable fast and frequent movements even within peak hours (P3; P4; P5; P12); FOT is "quicker and cheaper than driving in peak times in cities to use a courier to move goods" (P3). Literature agrees and states that Metro systems are accessible and punctual (Zhao *et al.,*2018); the service quality and travel times are attractive for FOT (Mazzarino and Rubini,2019). Also, cities with existing Metro and light rail systems have better feasibility for FOT (Hu *et al.,*2020b). The existing infrastructure also has links to all major urban centres (P4; P5; P13; Q5) and even in rural areas (P8); "we've got a moving transit vehicle going into destinations all over the country linked already in a network that exists" (P4).

Literature and experts state that for FOT there is an opportunity for attaching separate freight vehicles to passenger services (Cochrane *et al.,*2017; Liang and Tan,2019; DeLanghe *et al.,*2019; P3; P4; P5; P6; P12; P13). Authors note that attaching freight vehicles to passenger services is noted to be the most viable

option for FOT (DeLanghe *et al.,*2019; VanDuin *et al.,*2019). However, experts state the opposite, multiple experts believe that it would be difficult to hitch a separate freight vehicle (P4; P3; P12), especially to newer rolling stock (P4; P6; P12); the "ability to hitch just something that may be more difficult than historically it used to be but not necessarily impossible" (P6). Although, experts noted that an opportunity is to use existing spaces such as the guards vans (P2; P4; P5; P6; P8; P13) but "the guards van which we don't have anymore or modern trains" (P8), supported by others (P2; P6; P13).

A final FOT opportunity and sub-theme is the cargo volumes on FOT. The primary data mentions that FOT allows smaller business to access movement of goods by rail because FOT "can potentially serve markets that traditionally would not have used rail because the volumes weren't big enough" (P3). Literature mentions something similar, in stating that third party logistic firms can be used to consolidate goods (Islam,2018; Ursavas and Zhu,2018) to enable smaller firms to access rail freight (Islam,2018; Holguin-Veras *et al.,*2021), but for rail freight in general, rather than specifically for FOT. Also, experts explain that if EL is used, there is an opportunity to split the trains at an intermediate point to serve different areas (P3; P11) that that wouldn't necessarily have the volumes to justify a full train (P3); this can encourage more users of FOT. However, this area needs to be explored further as there is no specific literature on consolidation being used to encourage FOT.

Contribution to theory and practice:

There is a paucity around FOT and its characteristics in the literature, but this research has contributed to theory and practice in a number of ways. One poignant contribution to theory is that FOT is not a well-recognised term by experts within passenger transport and freight distribution. FOT is defined by multiple authors in the literature (Cochrane *et al.,*2017; Ozturk and Patrick,2018; Amaral *et al.,*2018; Galkin *et al.,*2019) however, out of the 18 experts who took part in this study, only one interviewee mentioned that they had heard of the phrase 'freight on transit'. This one participant is a transport professor and stated that "I probably worked it out … I think I must have seen it before somewhere because it was sort of familiar to me" (P8). A couple of participants who work for an infrastructure manager and answered the questionnaire guessed the definition of FOT and defined it as "freight carried by an existing mode" (Q4) and "I think this refers to the reconfiguration of passenger trains, so that some of the carriages can carry parcels and consumer goods" (Q3). However, because these questionnaires were filled out away from the researcher, the participants may have used the internet to look up the term. In hindsight there should have been a separate question asking whether they had heard of the term FOT, and then another question asking participants to define it. However, all participants were aware of the concept because they mentioned FOT as an option to better move LDHV into urban areas before being asked about FOT specifically. Therefore, the contribution to theory is the classification of FOT because the term FOT is too generic. This research has defined these characteristics as 'freight on passenger services' (FOPS) and 'express logistics' (EL). FOPS is where goods are placed on the same vehicle as passengers, this can include a separate carriage. EL is a dedicated freight service which is operating using a vehicle which has the same characteristics as a passenger train, this can include repurposing a previous passenger train, or the purchase of a vehicle which is also used by other operators as a passenger train.

Additionally, this research contributes to theory because this study is believed to be the first empirical study to recognise the environmental benefits of FOT, such as abrasive emissions. One participant noted that "one of the great benefits of rail freight is abrasive emissions are very very low" (P9); which are generated by breaks and tyres. This is an issue because these are the emissions that "health people are particularly concerned about" (P12) and participants agreed that EVs still produce these emissions (P9; P12); EVs may even produce higher abrasive emissions due to the weight of the batteries (P9). Additionally, another benefit of FOT is that there is "significant shielding with rail freight from users from particulates … because there is physical separation" (P9). All other studies (Behiri, Belmokhtar-Berraf and Chu,2018; Hu *et al.,*2020b; Singh and Gupta,2020; Jiang *et al.,*2020; Bruzzone, Cavallaro and Nocera,2021) in the literature

which note the environmental benefits of FOT are conceptual. FOT is an emerging conversation and the literature is dominated by analytical contributions, therefore this study contributes to theory because it is one of the few empirical studies discussing FOT.

This research also contributes to practice and is therefore of interest to practitioners. Participants recommended using stations as an urban multipurpose locations as an opportunity for urban freight because stations are often right in the centre of a city (P4; P5; P7; P13); "the ultimate aim of a lot of players in this market is to land in the city centres at what are basically passenger termini" (P7). Therefore, this is a contribution to practice, as the use of stations for urban freight distribution was mentioned by many participants so that goods can either be loaded onto trains or offloaded and stored at stations (P4; P7; P13; Q2). Additionally, one participant suggested that stations can be used as locations for passengers to pick up and drop off parcels (P8). Another practical contribution is to use empty retail spaces for urban freight activities such as storage and distribution to generate revenue for stations (P13; P7), this will be an opportunity post the coronavirus pandemic as many retailers have discontinued the use of their retail units at stations, meaning that there is an increase in empty retail units at stations (P13). This opportunity of the use of stations was not discussed much in the literature, the only mention was around the need for parcel hubs at stations (Zhao *et al.,*2018; Jiang *et al.,*2020); further exploration is needed into this in future studies.

An additional contribution to practice from the findings is that there is now more of an opportunity for FOT because of the drop in passenger numbers due to the coronavirus pandemic. Experts noted that a drop in passengers can free up capacity for FOPS and EL services (P2; P5; P11; P13), without the need for investing in infrastructure (P13). Experts also noted that passenger operators are showing a growing interest in FOT to increase their revenue (P4; P12; P13). There needs to be exploration as to whether there is now more of an opportunity and appetite for FOT due to the drop in passenger numbers, through comparing literature from before the pandemic and through new research post pandemic.

Another contribution to practice is that FOT is a "very simple way of offering it to the marketplace with very little risk" (P5) and that it "parcels on a seat is about as sophisticated as it needs to be" (P4). Evidence from a FOPS provider explained that FOT does not involve train operators staff or delay their services with 97% reliability (P12). It was also noted by most participants that FOT has operated in the past (P2; P5; P6; P8; P10; P12; P13; Q1; Q2), so any issues that do arise can be solved as they have in the past (P7; P13). However, there is a disparity between real life practice and theory. This empirical study notes that FOT is simple, yet the literature notes that FOT is an innovation method (Mazzarino and Rubini,2019) and complex (Nocera, Pungillo and Bruzzone,2020; Sun *et al.,*2020).

A final contribution to practice is the connection between FOT and the middle and final mile. The primary data noted that FOT is unable to facilitate the complete end-to-end supply chain (P1; P3; P4; P10; P12) and that the middle and last mile transport is still required (P8; P11; P12). Also, participants note the importance of road access at stations and termini to facilitate the last mile (P1; P4; P7; P11; Q3). One participant noted that an opportunity for practice is to load goods onto services in a depot before the start of a service, rather than at major stations (P13). None of these were stated in the literature; in fact, authors agree that FOT helps with last-mile distribution (Horl *et al.,*2016; Ozturk and Patrick,2018; DeLanghe *et al.,*2019; Agnieszka and Jagienka,2020; Bruzzone, Cavallaro and Nocera,2021). This may be because participants noted that stations are within the centre of urban areas close to where end customers are located (P4; P5; P7; P13). However, the literature does not expand on why FOT helps with last-mile distribution nor how FOT connects to the middle and last mile. The practicalities of FOT, its support and connection of middle and last mile needs further research.

Conclusion:

The aim of this research study was to explore the managerial considerations associated with freight on transit (FOT), in the context of the movement of low-density high-value (LDHV) goods into urban areas. The researcher chose to address this as they noted that there is clear paucity of empirical studies that explore the characteristics of FOT. The characteristics of FOT need to be explored because there are many challenges within the logistics and transport industry such as inefficiencies, the increase in policies restricting freight distribution into urban areas and environmental pressures; however, FOT could be part of the solution. This empirical research study has clearly outlined the characteristics of FOT using rail infrastructure and vehicles, which contributes to theory and practice to encourage the adoption of FOT to move LDHV goods into urban areas. This empirical study was conducted by firstly reviewing the current literature which identified the paucity of FOT literature, and qualitative data was collected from experts from within passenger transport and freight distribution to identify the characteristics of FOT in practice.

In summary, this research identified the characteristics of FOT: the benefits, challenges, and opportunities. There were many benefits of FOT highlighted through this empirical study; one of the main benefits of FOT highlighted in the literature and primary data is the speed that FOT can achieve, especially when compared to other modes. Participants note that FOT on rail reduces journey times in half for comparable road journeys, because FOT can reach speeds of over 100mph shortly after leaving a station or terminal, and that this speed can be kept for the whole journey. This contributes to practice as it allows couriers and retailers to have a later cut off time for delivery and that FOT can be used to address the courier-to-courier market. Additionally, FOT can be used for resource optimisation, which reduces energy and environmental degradation. Therefore, another benefit of FOT that has been highlighted through this empirical research is the societal benefits, including the reduction in traffic accidents and congestion, which are big challenges for road transport. Also, FOT is not restricted by policies within urban areas like road vehicles are. FOT can access stations in the centre of cities without any restrictions or additional charges, even in peak hours. FOT also creates a huge carbon saving, when compared to an equivalent road journey, especially where rail networks are electrified. Finally, it was noted by many that FOT is not a new concept and has operated in the past, and is an operation managed by specific, experienced FOT companies.

However, there have been examples of challenges of FOT. The specific challenges of FOT include the perception of FOT; it is perceived that FOT is unreliable, slow, inflexible and expensive, which is therefore a barrier to FOT adoption. However, this is not the case as participants demonstrate that FOT is reliable, simple, and economic, but investment is a challenge that has been highlighted. Additionally, capacity is also a challenge for FOT; capacity of rail networks in areas where there is high frequency of services is a challenge to schedule EL, but these frequent services can be used for FOPS. However, it is not just the capacity of rail networks, it is also the capacity at stations at terminals. A final challenge of FOT found through this study is security, there may be issues if dangerous goods are being carried alongside passengers and there is a risk that passengers may take or damage goods, yet there are examples of ways around this, such as separating passengers and freight; including separate EL services, locking out coaches for LDHV goods or hitching a separate vehicle onto passenger services.

There are also opportunities for FOT, including resource optimisation and exploiting existing underutilised infrastructure and services, to enable fast and frequent movements in a cost-effective way. Another opportunity is to attach a separate freight vehicle to existing passenger services to again help with resource optimisation. A final opportunity of FOT is that it can help reach potential customers to access rail as FOT allows smaller volumes of goods to be moved, rather than just facilitating businesses who have the volume to justify a conventional freight train, because retailers and customers can move single goods, goods in roll cage sizes using FOPS, or up to a full train for EL. There is also an opportunity to split EL services at intermediate points to serve different areas that also did not previously have the volume to justify a

conventional freight train. Therefore, FOT can be used to reduce the barrier to entry to rail and increase adoption of a sustainable mode of transport for freight.

The findings of this study contribute to theory in several ways. First, FOT is not a recognised term used within passenger transport and freight distribution. Therefore, this researcher has contributed to theory through classifying terms used within FOT, to distinguish between what is being discussed; the term FOT is too generic. This study found that there are two types of FOT; EL which is where a dedicated train is used to move LDHV goods with the characteristics of a passenger train, and FOPS where goods are carried on the same train as passengers, this could include in a separate carriage or by a separate vehicle hitched to the back. These classifications should be used to distinguish within theory because EL and FOPS have different benefits, challenges, and opportunities. Another contribution to theory is that this is the first empirical study to recognise the environmental benefits of FOT, previous studies have been conceptual. FOT has very few, if any, abrasive emissions which are emitted by road vehicles, including EVs. It is important that these emissions are reduced because they are detrimental to people's health. This is one of the few empirical studies that contributes to the emerging conversation about FOT which is currently dominated by analytical contributions.

The findings of this study may also be of interest to practitioners. Many participants noted that stations should be better utilised to help with the facilitation of FOT. Stations are ideal as they are usually in the centre of urban areas and often close to final delivery locations. There is also an opportunity to use empty retail units to store, distribute and collect goods for FOT as they are close to the FOT vehicle. However, there are some implications as stations are also used by passengers, therefore there needs to be some segregation between the two. Following on from this, another contribution to practice is that FOT should be utilised more for increased resource utilisation and revenue, especially due to the reduction in passenger numbers because of the coronavirus pandemic. This reduction means that there is more capacity on trains for FOPS and an additional revenue stream for passenger operators to support the running of their services. Also, the reductions of passenger services have meant that there is more capacity on rail networks for EL services, however it is not yet obvious what service levels will go back to once the pandemic is over. More researcher is needed once it is apparent as to the impact of the coronavirus pandemic on rail demand. An additional contribution to practice highlighted through this research is that FOT is not complicated in practice, FOT used to operate in the past. Literature states that FOT is an innovative solution and complex, when in practice participants who operate FOT state that FOT is not too complex and is feasible because it is economic, sustainable, fast and reliable. Therefore, a contribution to practice is that more advertisement is needed to retailers and distributors to encourage the use of FOT, due to the ease and benefits that it offers. A final contribution to practice is the connection between FOT and the middle and last mile. Participants noted about how modes such as cargo bikes, EVs and even drones could be integrated with FOT to distribute goods to the end customer. However, this was not well discussed in the literature, even though this is an important topic, because FOT needs to be part of an end-to-end solution for it to be viable.

To support the findings of this empirical research study, more research is needed because there is limited literature around FOT and its characteristics. Further research is needed to develop the themes identified throughout this research into a conceptual model which can then be validated through quantitative analysis. Additionally, as most participants had a rail background, more data is needed from those within the wider logistics and transport industry. During this study only two of the participants represented the wider logistics and transport industry, one being a transport professor and the other being the managing director for UK operations of a large parcel courier. Finally, future research is needed to understand the impact of coronavirus on the appetite for FOT, as some participants noted that there has been more of an interest from passenger operators due to the reduction in passenger numbers.

In conclusion, this research has filled the paucity within the literature around FOT and its characteristics, as well as contributing to practice. These findings should be used in practice because the benefits and opportunities highlighted through this research outweigh the challenges. Also, this research should be used to encourage the adoption of FOT to move LDHV goods into urban areas in an efficient and sustainable way, to overcome the challenges which are faced by the transport industry today.

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Appendix 1 – Interview and questionnaire base questions:

- What part of the industry do you currently work in?
- What are your thoughts on how low-density goods (e.g. parcels) could be moved into urban areas? Please consider all modes and note as many ideas as possible.
- What do you perceive to be the barriers/challenges of moving low density goods into urban areas?
- Do you know what freight on transit is? Please can you define what you think it is?
- Freight on transit is the movement of goods using public vehicles and/or infrastructure. What do you believe are the benefits of this?
- Freight on transit is the movement of goods using public vehicles and/or infrastructure. What do you believe are the challenges of this?

Appendix 2 – Consent form:

Information sheet for participants

Background

This research study aims to evaluate the options of moving low density goods in urban areas

This dissertation is part of a Masters Degree in International Logistics and Supply Chain Management at the University of South Wales.

Your participation

You are able to take part in this study as you have current or previous experience of the transport industry. You will only participate if you are happy to be part of the project and have signed a consent form.

You are asked to:

- Take part in an interview
- Speak as honestly as possible
- Give your view on urban freight transport for low density goods

Any information you give in the interview will be kept private, confidential and anonymous and you do not have to answer any questions you do not feel comfortable with. Your name and any other identifying information will not be disclosed in any publication.

What will happen next?

After the interview has finished, the recording of you voice from the session will be listened to by the researcher, written up, and kept private, confidential and anonymous.

The information gained from your interview will mean that the researcher will be able to assess how low-density goods can be moved into urban areas.

For any further information please contact myself or my dissertation tutor where we will be happy to answer any questions that you may have.

Researcher – Alice Bulpin – Alice.Bulpin@networkrail.co.uk OR 14544831@students.southwales.ac.uk
Tutor – Stuart Milligan – stuart.milligan@southwales.ac.uk

Consent form for participants

Dissertation topic: Movement of low-density goods into urban areas

Name of Researcher: Alice Bulpin

For participant – Please only sign if you accept all of the below statements

1. I have read all the above information about this study and understand what is involved as my role of the participant.
2. I understand I am able to drop out of the study at any time if I am not happy, due to voluntary participation.
3. I will be as truthful as possible during the interview, with the information I give being kept confidential and anonymous.
4. I understand that my participation in this study will not affect my relationship with the researcher.
5. I agree to be part of this study.

_____ _____

Name of Participant Date

_____ _____

Signature of Participant Date