Understanding the transport impacts of on-demand meal deliveries: A London case study

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ABSTRACT

The rise of the on-demand economy has led to a rapid increase in the delivery of ready-to-eat meals by delivery drivers (DDs) using bicycles, mopeds and cars, with newly-established platform providers handling order and payment processing and in some cases, the co-ordination of drivers. Little is currently understood about the collective transport impacts of such activity in urban centres and to what extent this poses challenges for transport policymakers. Using a substantial database of 40,941 meal deliveries made by 195 couriers over 3 months in central London, this paper quantifies these impacts and discusses the transport and environmental implications of such activity along with the policy options for mitigating the negative impacts. The results suggested that the vast majority of DDs (83%) used a petrol moped, with 10% and 7% using a car and bicycle respectively. On average, 9.6 deliveries were undertaken by a rider daily, with each taking 25 minutes from pickup to delivery with an average trip length, from restaurant to customer of 2.2km (1.4 miles) and a DD travelling 41.3km (25.7 miles) in total per day. Around 49% of the riders time was found to be productive (making deliveries) during a typical day in November/December with 63% of all meals (n=22,100) being collected between 17:00 and 22:00 with lunchtime activity being substantially lower by a factor of 2.75 until 16:00.

The findings suggested that mopeds (340kg of CO2e/tonne) and cars (716kg of CO2e/tonne) emit, respectively, 5 and 11 times more GHGs per meal delivered than bicycles (64kg of CO2e/tonne), and with some national fast-food chains generating on average 70 deliveries per day, there are growing concerns around the transport intensity of these activities. With a meal delivered by car being responsible for approximately 1300 times the distance travelled and 200 times the GHG emissions of an articulated HGV operation per tonne delivered, there is a need for policy makers to promote the use of electric modes in this sector.

HIGHLIGHTS

- Operating, environmental and safety issues of meal delivery reviewed.
- Average of 10 trips per day by a driver in November/December 2017 dataset analysed.
- Mean one-way trip distance for meal delivery is 2 km taking at 5.5 km per hour.
- Greater GHG and kerb occupancy impacts for car/moped than bicycle meal deliveries.
- Greater vehicle kms for meals than other freight operations per tonne delivered.

KEYWORDS: Fast food, ready-to-eat, home delivery, on-demand, platform providers.

INTRODUCTION

The rise of the on-demand economy has led to a rapid increase in the numbers of online orders for ready-to-eat meals (referred to as ‘meals’ in the paper). In order to fulfil these orders, there has been significant growth in crowd-sourced delivery drivers (DDs), creating new informal logistics networks of people willing to service restaurants and takeaways and deliver meals to customers (McKinnon, 2016). In the UK, Deliveroo, JustEat, and UberEats are the main companies providing online platforms that link customers to restaurants. In the rest of Europe, similar platform providers include Delivery Hero, Takeaway.com, and Foodora / Foodpanda (the latter also having a major presence in the Far East), while in America, GrubHub and UberEats are major players. Most of these platform providers utilise self-employed DDs who use their own vehicles, typically mopeds (i.e. motor driven cycles with an engine capacity not greater than 50 cc), bicycles and cars to make deliveries.

This fast-growing sector is placing additional pressure on an already congested kerbside infrastructure and is imposing new transport and planning challenges on towns and cities. This new source of urban freight transport has received little attention to date from researchers and policymakers and this paper makes three contributions to research in this topic: firstly, it provides a comprehensive review of the literature related to the last-mile meal delivery market and its operations and impacts in the UK. Secondly, through empirical analysis using an operational dataset from a meal delivery platform provider, it quantifies the transport characteristics and environmental impacts of last-mile meal deliveries in London. Thirdly, it sets these meal deliveries in context with other forms of urban freight transport in terms of their environmental impact, thereby providing insight into the challenges posed for urban policymakers.

METHODOLOGY

A literature review was carried out into the relevant topics associated with meal deliveries, identified from initial interviews with policy makers in London, and with managers and DDs working in the meal delivery sector through the Freight Traffic Control 2050 project (www.ftc2050.com). The topics covered include: the last-mile meal delivery market and its operations in the UK, delivery driver's perspectives, working entitlements and safety along with evidence of vehicle trip generation at takeaways and restaurants. Key academic literature on this topic comes from Dablanc et al., (2017), Fincham, (2006, 2007, 2008) and Kidder, (2004, 2005, 2009). The meal delivery market, its delivery operations and their impacts, has been subject to relatively little academic research with the vast majority of material concerning these topics written by business journalists and trade reporters.

To corroborate the findings from the literature review, a significant database of operational delivery data was obtained from a major 'on-demand' platform provider serving restaurants in and around Greater London covering two time periods in 2017. This dataset was analysed using a spreadsheet to quantify the transport impacts associated with meal delivery in parts of London and confirm key operational parameters.

Using the findings from this case study data, the GHG emissions and transport intensity of meal deliveries across London were estimated and compared against the freight and personal trips associated with food purchased in a supermarket and cooked at home. Generalised vehicle emissions factors were used in order to compare the impacts of different vehicle types (DBEIS and DEFRA, 2017; European Cyclist's Federation, 2017) in these settings. Data on oven cooking was taken from governmental and academic sources (DBEIS and DEFRA, 2017; Calderón, 2018). Comparisons between the GHG emissions and transport intensity of meal deliveries and other types of urban freight transport in London using traditional freight vehicles (vans, rigid and articulated heavy goods vehicles) was carried out using data collected in survey work in London (Allen et al., 2018a), disaggregation of vehicle activity in London from the UK Continuing Survey of Road Goods Transport (Allen et al., 2014), vehicle dwell time surveys (Cherrett et al., 2012), and the sources of vehicle emissions factors quoted above.

LITERATURE REVIEW

Rapid growth and changing business models in the ready-to-eat meals delivery market

All deliveries of restaurant and takeaway meals are undertaken on a same-day basis with an order being placed by a customer direct via telephone or online via a platform provider and a meal delivered to the home or location of choice of the customer within a specified time period. This sector has existed in the UK for several decades but until recently had been dominated by independent takeaways and restaurants that took their own orders by telephone and organised deliveries themselves. In the 1990s, takeaway chains especially in the pizza sector (including Dominos, Pizza Hut, and Papa Johns) became important drivers of growth in delivered meals. In recent years, the sector has been revolutionised by 'on-demand' platform providers that take orders online on behalf of restaurants and takeaways and in some cases also carry out deliveries on their behalf. These start-ups include Just Eat, Deliveroo, Uber Eats and Amazon. The internet has been an important facilitator in this growth and it is estimated that over onethird of all eating establishments in the UK (around 35,000) now use online apps to support customer ordering (Just Eat, 2017), with 31% of respondents in one survey placing meal orders via a website that also provides delivery services (Statista, 2017). Other factors that have fuelled the growth in this sector include consumers wanting to save meal planning, cooking and shopping time, together with the increase in restaurants and takeaways providing delivery services (Mignot, 2015).

The market for ready-to-eat delivered meals

The worldwide market for delivered meals was estimated to be $97 billion in 2016, representing 4% of meals sold through restaurants and fast-food chains (Hirschberg et al., 2016). In the UK, the total order value of this market has been estimated at between £6.1 and £7.1 billion in 2017 (Just Eat, 2018; MCA, 2017), accounting for 332 million orders annually (MCA, 2017). This sector has experienced 50% growth since 2008 (NPD, 2017) and is forecast to achieve an annual growth rate of 10-15% over the next few years (Hirschberg et al., 2016; NPD, 2017), attributed in the main to the expansion in online delivery platforms.

In contrast, the market for eating out in UK restaurants only grew by 1% in 2016 (NPD, 2017), with research indicating that approximately 40% of consumers dine out less as a direct result of the growth in online meal delivery options (Price, 2017a).

Demand for ready-to-eat meal deliveries

Traditionally, last-mile meal deliveries were associated with takeaway fast food but latterly, full-service restaurants and pubs are entering the marketplace, enabled by the on-demand platform providers, generating considerable transport activity (Khomami, 2017). Periods of peak demand coincide with lunchtime and evening meals, while growth in the delivery of breakfasts has also been reported (NPD, 2017). A customer survey across sixteen countries suggested that 74% of all orders placed via such platforms were between Friday and Sunday with 82% for home delivery and 16% for a workplace (Hirschberg et al., 2016). The average order value in the UK (2017) was estimated to be £21.45 (MCA, 2017) with 60% of customers stating that speed of delivery was the most important factor in their choice decision with a maximum waiting time to receipt of no more than 60 minutes (Hirschberg et al., 2016).

Key players in the UK online delivered meal market

Just Eat is the largest meal platform provider in the UK (accounting for 56% of its total worldwide revenue), working with 82,300 restaurants and takeaways worldwide, accounting for £3.3 billion total food spend, and 172 million orders in 2017 (Just Eat, 2018). It originally only provided an ordering and payment platform for its restaurants but in 2018, announced plans to launch its own delivery fleet, with £50 million planned investment (Monaghan, 2018).

Deliveroo launched its meal delivery service in the UK in 2013 and operates in 81 cities globally, working with 15,000 restaurants that would not otherwise offer takeaway deliveries. It provides delivery services via its network of self-employed DDs. The company has approximately 15,000 DDs in the UK (Warne, 2017a; Ainsworth, 2017) and its sales had increased by 116% to £277m by 2017 (Chapman, 2018a), generating about $1 billion of venture capital in its five-year life (Satariano, 2018).

Uber (UberEats) and Amazon Restaurants entered the UK meal delivery market in 2016 and provide their own delivery services via self-employed DDs (Auchard, 2016). Amazon Restaurants commenced its delivery service with 100 restaurants in specific London postcodes in September 2016 (Farrell, 2016). In addition to these online platform providers, the three leading takeaway pizza providers in the UK provide their own delivery services with Domino's Pizza having approximately 1000 outlets, and Pizza Hut and Papa Johns approximately 400 outlets each (Mintel, 2017a).

The ordering and delivery process for online ready-to-eat meals

The transportation activity in these transactions can be managed in one of two ways:

i) **By the food outlet**, where the platform providers act as 'order-only' marketplaces, providing websites and mobile apps to organise orders for takeaways and restaurants, charging commission of around 10-15% of each order value, with the restaurant organising the transport (BMI Research, 2016).

ii) **By the platform providers themselves**, where they not only process orders for food outlets but also manage deliveries through a dedicated fleet of DDs in what is termed 'on-demand' marketplaces. The restaurant is typically charged a commission of 25-30% of the purchase price. These platforms typically have the following functionality:

- *Requisitioning DDs* – estimating in advance how many DDs will be needed at any given time and inviting registered DDs to sign up to work in certain areas at certain times. In the case of Deliveroo, some DDs can book work sessions in their preferred area(s) up to one week in advance and priority booking privileges are given to DDs that work peak periods (e.g. Friday, Saturday and Sunday evenings) and who do not cancel sessions (Deliveroo, 2017).
- *Allocating jobs* – using an often automated approach to link DDs to restaurants and consignees taking into account their live location and the estimated time to travel to the restaurant, based on their specified mode of transport (Deliveroo, 2018a).
- *Monitoring jobs* – logging of the various stages of an individual transaction in time (e.g. order placement, job allocation to DD, order collection from restaurant, delivery).
- *Navigation* – assisting the DD to find collection and delivery points.

Delivery and driver characteristics

Meal delivery is offered in urban areas where journey distances from the food outlet to the point of delivery are often less than 3 miles to achieve a rapid delivery response at lowest cost. It is a point-to-point, immediate delivery service typically taking 15-45 minutes from when the order was placed, with little scope for DDs to carry more than one consignees order at a time. Deliveries. Even taking these small catchment areas into account, evidence suggests that it is difficult for DDs to achieve more than two deliveries per hour, paid at around £4-£5 per delivery or £9.50 per hour (Cycling Plus and Ainsley, 2016; Fedor, 2016). Sharp peaks in meal delivery demand present a logistical challenge, requiring large numbers of DDs for relatively short periods, explaining why some platform providers do not offer a delivery service (Ahmed, 2017). Mopeds, bicycles and cars are the most commonly used vehicle types, typically provided by the DD, but with some pizza chains providing mopeds. DDs are typically provided with an app-based navigation system to assist them in travelling between restaurants and delivery points.

A study of companies deploying meal DDs in London found that for nearly three quarters of responding companies, the majority of DDs they deployed were aged between 21 and 30 (Synovate, 2007). Internal surveys at Deliveroo showed that 85% of DDs had another job and 60% were under the age of 25 (Warne, 2017b). A survey by Deliveroo of 900 of its DDs in June 2017 suggested that 90% of them did not consider the job as their main source of income with 72% delivering at least one order in a particular week and working fewer than 15 hours per week; 19% working between 15 and 29 hours per week; and 9% working 30 hours or more (Field and Forsey, 2018). DDs working for platform providers are typically self-employed while some of those working directly for individual restaurants and restaurant chains are employees or dependent workers.

Delivery driver perspectives

Some meal delivery (and parcel) cycle DDs have a passion for, and interest in their work that extends beyond the practicalities of the tasks involved, deriving a sense of satisfaction from their work and the relationships built up with others performing the same role (Cycling Plus and Rob Ainsley, 2016). Research and writing about this DD cycling subculture has mostly focused on the parcel delivery sector, as this has been in existence far longer than the meal delivery sector. Sociological studies indicate that for those who feel part of this subculture, it is strongly related to the transport mode used as well as the work itself (for example, see Kidder, 2004; 2005; 2009 and Fincham, 2006; 2007, 2008).

In addition, several cycle DDs in the UK have written memoirs about their work and social lives in this world (for UK examples, see Chappell, 2016; Day, 2015; Sayarer, 2016). Some meal delivery cycle DDs have formed online chat forums that go beyond simply exchanging work tips, also involving long distance leisure rides (Cycling Plus and Rob Ainsley, 2016; Roo Community - Deliveroo Riders, 2018).

There are several negative aspects of cycle DD work, including typically having no paid holidays, no sick pay, ensuring bad weather and being exposed to increased road safety risks, and sometimes encountering irate and rude customers (Cycling Plus and Rob Ainsley, 2016). For some cycle DDs, this is outweighed by the positive aspects of the work (Kidder, 2009) with some viewing the job as an opportunity to get paid to exercise (Long and Butler-Roberts, 2017). A London-based parcel cycle DD who wrote memoirs of their experiences estimated that approximately one in five cycle DDs were bohemians and enjoyed the image of being a cycle DD (Sayerer, 2016).

Employment status and workers' rights issues

The employment status of meal and parcel DDs (using any mode of transport and often referred to as being part of 'the gig economy') has received much political scrutiny in the UK, along with other sectors that also make use of self-employed, especially manual, workers (Taylor Review, 2017; Allen et al., 2018b). The same situation has also been noted in France (Dablanc et al., 2017).

A key complaint from meal DDs relates to unpaid time associated with waiting for jobs to be allocated by the platform provider and for restaurants to prepare orders (Indeed, 2018). Platform providers tend to oversupply DDs to ensure fast deliveries, and there has been much criticism and negative publicity surrounding the perceived exploitation of DDs, with legal challenges and a UK Parliamentary enquiry about poor working conditions, low pay and infringements of rights (Butler, 2018a; Wilcock, 2018). Some DDs have staged industrial action with groups of UberEats DDs carrying out strikes over pay and demanding a minimum delivery fee in September 2018 (Lomas, 2018; Siddique, 2018). The IWW (Industrial Workers of the World) union called a strike among meal DDs on 4th October 2018 in several British cities including London, Glasgow, Cardiff, Bristol, Newcastle and Plymouth (IWW, 2018).

Deliveroo DDs in London attempted to have their independent worker status (i.e. self-employed) altered to dependent worker or employed status through legal action commencing in November 2016 (IWGB, 2016d). However, a High Court judicial review of the decision by the Central Arbitration Committee (CAC) ruled in December 2018 that the DDs were not workers or employees as they were able to pass on a job to a substitute DD or abandon a job (Butler, 2018b). Their status therefore remains as self-employed.

Following the Taylor Review (Taylor Review, 2017), Deliveroo began offering income protection and public liability insurance to its DDs for a fee (Deliveroo, 2018b). In May 2018, Deliveroo announced it would introduce a new free accident insurance scheme for its DDs which provides cover for medical expenses and 75% of gross pay as replacement income for up to 30 days of inactivity in case of injury at work (Makortoff, 2017; Roberg, 2018; Tassinari, 2018). Uber responded to the Taylor Review and the government's response to it by stating that it would establish a feedback programme to make it easier for DDs to raise issues and ideas to the company on working changes and decisions. It also committed to setting up advisory groups in every British city it operates in, comprising local DDs and senior Uber staff each month (Haslett, 2018). In January 2018, Uber Eats launched a free personal insurance scheme for self-employed DDs (Fioretti, 2017; Lomas, 2018).

Environmental, health and wellbeing impacts of bicycle DDs in urban areas

Cycling as a mode for home delivery is associated with reducing greenhouse gas emissions and local air pollution compared with other vehicle modes such as mopeds and cars. However, although manual and electrically-assisted cycles (and cargo-cycles) are emissions-free at the point of use, there are CO_2e emissions associated with electricity generation as well as with the extra food and drink consumption that a cyclist requires compared to a motorbike, car or van driver. These have been calculated to be approximately 16 g CO_2e / km for a cyclist and 6 g CO_2e for an electrically assisted bike user (European Cyclist's Federation, 2017). Research has also shown that the manufacture of bicycles is associated with fewer greenhouse gas (GHG) emissions than other vehicles (approximately 5 g CO_2e / km for a bicycle or assisted cycle compared to 42 g CO_2e / km for a car) (European Cyclist's Federation, 2017).

Research has shown that cycling leads to increased overall physical activity, rather than substituting other forms of physical activity and could thereby lead to improved physical health (Donaire-Gonzalez et al., 2015, Rojas-Rueda et al., 2016). While cycling typically leads to an improvement in fitness, it does expose the rider to toxic fumes, and the increased risk of traffic collisions (de Nazelle and Nieuwenhuijsen, 2010).

Traffic incidents and casualties among DDs

Forty two per cent of respondents in a recent online survey of UK DDs and taxi drivers using bicycles, motorbikes or cars reported that their vehicle had been damaged as a result of a collision while working, with a further 10% reporting that someone had been injured (either themselves or another road user) (Christie and Ward, 2018). In a 2006 survey of meal delivery companies, 25% of respondents reported that one or more DDs had been injured in a traffic collision in the previous twelve months. Of those meal delivery companies who had at least one DD injured, 18 stated that the DD was slightly injured and 8 stated that the DD was seriously injured (Synovate, 2007). A survey of 160 meal DDs in Australia found that 50% had been injured on the job or knew a colleague who had with many also reporting damage to their bikes (Zhou, 2018). A study of bicycle DDs in Montreal found that they were six times more likely to be involved in collisions than other cyclists due to the distance the DDs covered and the amount of time spent on the road (Messengerville, 2008).

In China it has been estimated that there were three million DDs in 2017, with the vast majority working wholly within urban areas using mopeds. In the first six months of 2017, 76 injuries and deaths involving meal DDs were reported in Shanghai while in the city of Nanjing, it was reported that meal DDs were involved in more than 3,000 collisions in the first half of 2017, of which DDs were responsible for more than 90% (Shepherd, 2017).

Meal delivery driver behaviour on the road network

Using data from the millions of actual journeys its DDs have completed, Deliveroo reported that cycling journey times can be lower than mopeds and cars in dense, busy urban areas in the UK due to road traffic levels, the provision of cycles lanes, the manoeuvrability of bicycles, and the difficulty of finding suitable on-street parking for mopeds and cars (Reid, 2018). DDs may also ride quickly in their haste to complete work and earn more pay which can involve some risky and/or illegal behaviour such as weaving in and out of the traffic, riding the wrong way along one-way streets and riding on pavements (Marsh and Boswell, 2016; Zhuravlyova, 2018).

The riding behaviour of meal DDs is likely to be related to several governance and demographic factors: their self-employed status (whereby the faster that jobs can be carried out, the more the DD can earn); the young age profile of meal DDs with many having had little experience on the road prior to being engaged as DDs; and the limited amounts of training offered and taken-up. A UK study of self-employed DDs and taxi drivers, involving in-depth interviews and an online survey, found that none of those interviewed were required to have training or were given training other than being informed of online videos, while 63% of survey respondents were not provided with safety training on managing risks on the road (Christie and Ward, 2018). This same survey also found that that 67% of respondents reported that the company did not suggest they had rest breaks and did not give advice about using their phone whilst driving or riding. Forty per cent of respondents using an app as part of the work reported that they found them too off-putting while driving or riding. Across both two and four-wheeled DDs, only 25 per cent agreed that the company cared about their safety whilst working (Christie and Ward, 2018). A survey of 160 DDs delivering meals by cycle in Australia found many reporting that they received little or no training (Zhou, 2018).

The majority of meal deliveries take place in the evening which increases the risk of collisions. Riding two wheeled vehicles in poor weather also increases the risk of collisions and the severity of any traffic incidents. Meal DDs working at night (or even during the daytime) making deliveries to residential addresses may be confronted by aggressive or drunken customers and working alone after dark, and sometime handling money, can also make such work dangerous (European Agency for Health and Safety at Work, 2010). In the last couple of years in the UK, attempts to steal DDs' motorcycles, mopeds and bicycles have led to acid attacks on some DDs that have resulted in life-changing injuries (McGoogan, 2017).

Trip generation, noise and nuisance at food outlets

Meal deliveries can have substantial impacts on local vehicle-based trip generation:

i) these deliveries emanate from high street restaurants and takeaways, with some outlets generating substantial vehicle activity;
ii) these trips largely occur within short peak periods of demand, especially in the evening from 18:00, so can conflict with evening peak road traffic;
iii) these restaurants and takeaways usually have no off-street parking space, so all mopeds and cars make use of on-street kerbside space;
iii) vehicle dwell times while DDs wait for orders to be cooked and packed at the restaurant/takeaway are considerably longer than the time taken for a delivery to reach the final destination. This can result in sizeable numbers of vehicles and drivers congregating outside a single food outlet waiting for deliveries to become available;
iv) many bicycle DDs choose to mount the kerb with their vehicles taking considerable pavement space and moving them across the pavement can lead to conflicts with pedestrians;
v) DDs waiting for deliveries outside a restaurant can make considerable noise while socialising. However, they are usually not employed by the restaurant, which is therefore not responsible for their conduct. Given that meal deliveries continue late into the night, this can lead to considerable noise disturbance for residents living in close proximity to the restaurant/takeaway (Allen et al., 2018b).

The negative impacts associated with meal collections have become a recognised problem in some dense, mixed-use urban areas, where residents and restaurants are located close to each other. In the City of Westminster in central London, the council received more than 25 complaints from residents living close to a fried chicken shop. These residents said they were repeatedly disturbed by large groups of DDs waiting for orders in the street, with 3-4 mopeds parked up outside the restaurant at any one time after 19:00, and several hundred delivery vehicle trips generated over the course of a weekend (Hexter, 2017). Westminster City Council is currently seeking to establish a policy for meal and other deliveries as part of its new City Plan (BBC News, 2017; Price, 2017b).

Deliveroo has started to introduce stand-alone kitchens, which they refer to as 'RooBoxes' and 'Deliveroo Editions kitchens', but which critics refer to as 'dark kitchens' (Butler, 2017; Mintel, 2017b; Neilan, 2017). Each development can comprise several different meal providers and have recently appeared in several London locations. They are located in metal shipping containers, disused carparks and industrial buildings (Pathiaki, 2017). Some of these facilities have been built in close proximity to residential accommodation and can generate up to 200 vehicle trips per hour (Morris, 2018, Satariano, 2018), leading to complaints concerning traffic generation by mopeds, motorbikes and vans; danger of traffic collisions with pedestrians; poor driving behaviour; and vehicle and DD noise during the evening and night (Hexter, 2017).

Deliveroo had planned to open 200 such kitchens in the UK by the end of 2017, but this was not realised due to the complaints and planning investigations that have resulted (Butler, 2017). Deliveroo has stated that it is considering using more bicycle DDs to deliver food, instead of mopeds, to reduce noise disturbance where that is a particular problem (Butler, 2017). It is also putting in place other mitigation measures to try to ensure that DDs only arrive at the kitchen when meals are ready, the provision of DD waiting areas inside the kitchens, and assembly points in areas as far from any nearby residential properties as possible (Deliveroo, 2018a).

LONDON CASE STUDY

Road traffic and its associated GHG and air quality impacts have been worsening in London. This has led consecutive Mayors of London to implement mitigating policy measures including the Congestion Charging Scheme (in 2003), the Low Emission Zone (in 2008) and the Ultra Low Emission Zone (commencing in 2019). Traffic speeds have fallen and delays increased across London over the last decade (Transport for London, 2016) as demand for kerbside space has increasing, with one central London authority having recently documented 39 different uses of the kerbside, of which deliveries and collections only represented a single entry (Westminster City Council, 2018).

Understanding the transport impacts of meal delivery operations

DD data were supplied by a major platform provider serving restaurants in and around Greater London, UK. An initial dataset comprising deliveries during the period 10-30 July 2017 (see Figure 1) was used to develop and illustrate the methods used while a larger dataset, covering November-December 2017, provided added robustness and a seasonal comparison. Each data record contained latitude/longitude coordinate pairs for the trip origin (e.g. a restaurant) and destination (delivery address), the date and times of collection and delivery, and a unique DD identifier number. The vast majority of DDs (83%) used a moped, with 10% using a car and 7% using a bicycle. All delivery trips were associated with a single collection and delivery with return trips from a delivery location to the next restaurant collection inferred using the DD ID. Trip distances were obtained for all cycling and driving trips using the Google Maps Distance Matrix API with driving distances found to be approximately 10% greater than cycling distances on average.

The trips displayed a spatial pattern in which collection points (i.e. restaurants) are concentrated and delivery points are dispersed in the surrounding neighbourhoods, radiated out from the collection points (see Figure 1 – left hand map). This spatial pattern was examined further by overlaying a 500m (1640 foot) grid over the study area, counting the number of collections and deliveries in each cell, and visualising the difference of the two values. The resulting heatmap (see Figure 1 – right hand map) shows a clear relationship, with collection points (i.e. restaurants, shown in red) placed centrally, and delivery locations (in blue) distributed around them. Both maps clearly show the areas of London that were served by this operator during this period.

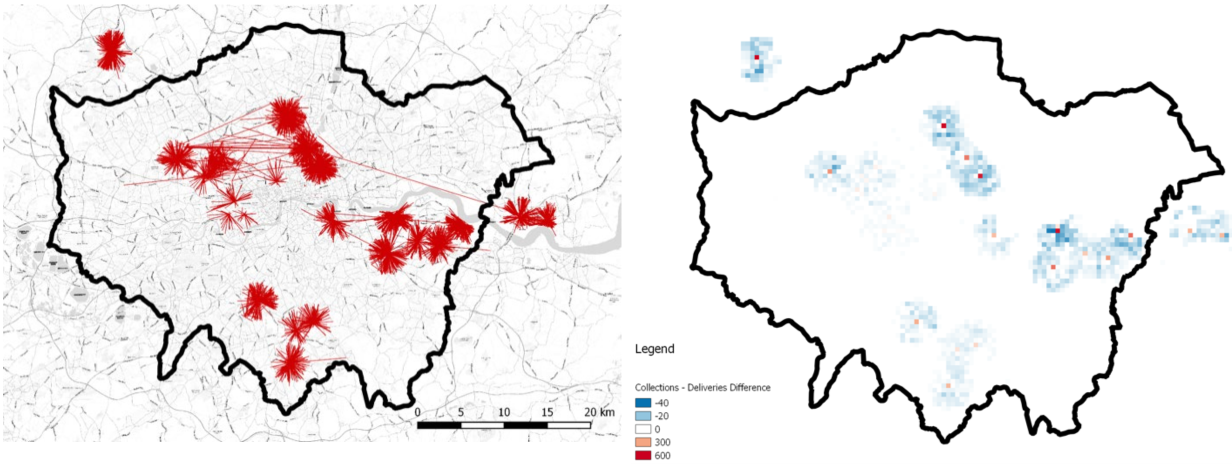

Figure 1. Left hand map: Delivery trips made by DDs working for one platform provider (restaurants to customer) during July 2017 (Greater London area shown). Right hand map: Heatmap in which blue hues signify more deliveries, and red hues more collections per cell.

The July 2017 data contained 7,918 deliveries over 21 days (377 deliveries/day), serviced by 85 DDs, while the November/December dataset had 33,023 deliveries over 60 days (550 deliveries/day), serviced by 110 DDs with individuals being generally busier in November/December than in July (Table 1). Comparing the time spent making deliveries with the total work session length suggested that only 38% of time was productive during July, whereas this increased to 49% in November/December with less time being spent waiting for the next job to be allocated.

During November/December, the average number of jobs worked each day was 9.6, with each job taking 25 minutes on average from pickup to delivery with an average trip length, from restaurant to customer, of 2.2km (1.4 miles). The average distance travelled by a DD in a day was 41.3km (25.7 miles), not including commuting to and from home, of which half the distance was associated with return trips from customers to the next restaurant. The maximum number of deliveries made by a DD on one day was 27. The mean and median delivery speeds, derived from the time and distance data, were both estimated as 5.5km/hr (3.4 miles per hour) although the time used may include some time at the vehicle (e.g. loading food) and at the customer.

Investigating the number of days worked by each DD revealed a broad spectrum, ranging from 1 day only (3 DDs) to 56 days out of the 60 working days in November/December (2 DDs). Of the 85 DDs seen in July, 25 were no longer working in November/December and 50 new DDs were introduced in the latter dataset, suggesting the relatively high turnover rates associated with this type of work.

Table 1. Delivery driver statistics related to food delivery activity associated with one platform provider for July 2017 (85 DDs) and November/December 2017 (110 DDs) in London

		July		**Nov/Dec**	
		mean	**median**	**mean**	**median**
Number of jobs per DD day		7.5	7	9.6	9.0
Percentage of days worked per DD		57%	67%	51%	56%
Duration (hh:mm)	Individual one-way delivery trip	00:19	00:17	00:25	00:25
	Daily one-way delivery trips total	02:27	02:15	03:21	03:42

	Work session (includes time between trips)	06:31	07:06	06:53	07:05
Distance (km)	Individual one-way delivery trip	2.0	2.0	2.2	2.2
	Daily one-way delivery trips total	16.0	14.8	20.9	20.4
	Work session (includes return trips)	29.4	27.3	41.3	38.9
Delivery speed (km per hour)		5.4	5.4	5.6	5.6

Investigating restaurant collection times across the November/December dataset demonstrated an evening peak profile, with 63% of all meals (n=22,100) being collected between 17:00 and 22:00 with lunchtime activity being substantially lower by a factor of 2.75 until 16:00, when the evening peak starts to build. There was minimal activity in the morning and after 23:00.

Research by Juhari (2018) attempted to quantify the likely total number of DD journeys originating from all the 'on-demand' delivery platforms used by three individual fast food restaurants (part of a national chain) located in Wood Green, Stoke Newington and Hackney Central. Figure 2 shows the origin points of meals destined for delivery from all outlets in the dataset across these three areas of London (red squares), highlighting the density and number of restaurant and takeaway outlets engaged in home delivery. The data from the 10th to the 30th July 2017 suggested that each of the three restaurants generated 26.7 (Wood Green), 24.3 (Stoke Newington) and 24.8 (Hackney Central) delivery orders via the platform per day on average (Wood Green (SD 12.7, Min 8, Max 51); Stoke Newington (SD 12, Min 1, Max 47). Of interest is the number of online orders placed with these restaurants across all the platforms used, in this case, Just Eat, Deliveroo, Uber Eats and Hungry Pander. From a survey of restaurant and fast food outlets in Southampton (n=18), the use of 'on-demand' delivery platforms by restaurants was made up of Just Eat (24.7%), Deliveroo represents 39.9%, Uber Eats is 8.6%, Hungry Panda is 6.7% and an outlet's own system, 19.4% (Juhari, 2018). Using these figures, the results suggested that the three restaurants, who all took online delivery orders via multiple platforms may have delivered 70.5 (Wood Green), 64.2 (Stoke Newington) and 65.5 (Hackney Central) orders per day on average.

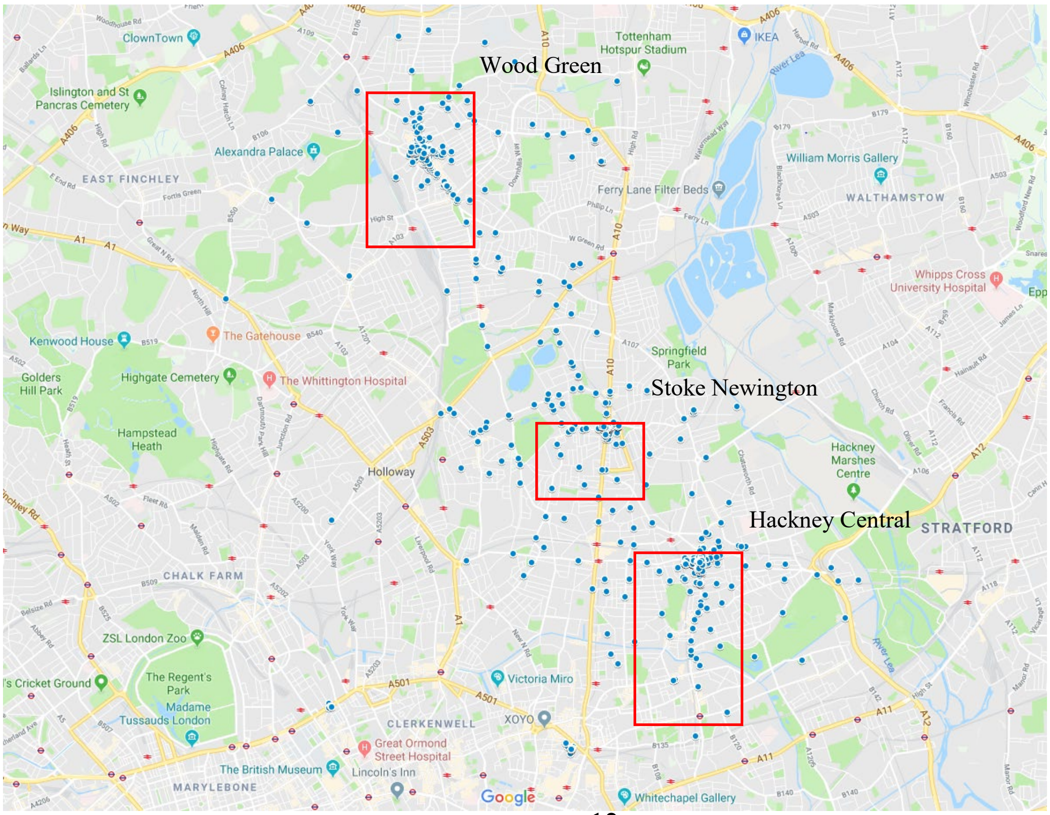

Figure 2. Restaurant and takeaway establishments generating online deliveries across the Wood Green, Stoke Newington and Hackney Central areas of London between the 10th and 30th July 2017.

Transport intensity and greenhouse gas emissions from meal deliveries

Using the delivery data provided by the meal delivery operator along with interviews with managers and DD drivers about their operations and parking strategies, a spreadsheet-based analysis was carried out to quantify i) the GHG emissions (expressed in grams of CO_2 equivalent - CO_2e - comprising CO_2, CH_4 and N_2O) per tonne of delivered product, and ii) the transport intensity (expressed in terms of the distance travelled along with the road and kerbside parking space occupied per tonne delivered) associated with meal deliveries in London by vehicle type (Table 2). Kerbside space and time occupancy were calculated by multiplying the width and length of vehicles by the time vehicles spent at the kerbside, expressed in the unit m^2hrs.

The results indicated that although the distance travelled per tonne delivered (4,000 km) is the same for all vehicle types (given that the journey distance and load are the same in each case), mopeds (340kg of CO_{2e}) and cars (716kg of CO_{2e}) have far greater impacts in terms of GHG emissions per tonne delivered compared to bikes (64kg of CO_{2e}). Similarly, road and kerbside occupancy levels were greater for mopeds (1.6m^2 and 323 m^2hrs/tonne) and cars (8.1m^2 and 1620 m^2hrs/tonne) compared to bikes (1.2m^2 and 0 m^2hrs/tonne) with the latter either taken direct to the door or parked on the footway during collection and delivery. The results suggested that mopeds and cars emit, respectively, 5 and 11 times more GHGs per meal delivered than bicycles. The far greater length and width of a car results in it occupying approximately five times greater road space when travelling, and five times greater kerbside occupancy than a moped.

Table 2. GHG emissions and transport intensity of meal deliveries in London studied

Vehicle used	GHG emissions per tonne of product delivered (kg of CO_2e/tonne)	Distance travelled per tonne of product delivered (km)	Road space occupied by vehicle (m^2)	Kerb occupancy by vehicle while parked per tonne delivered (m^2hrs/tonne)
Bicycle	64		1.2	0
Moped	340	4,000	1.6	323
Car	716		8.1	1,620

Notes:
All journeys assumed to be point-to-point involving a single meal transported from restaurant to delivery point; assumed average each-way journey distance of 2 km.
Average of collection time of 10 minutes at restaurant which includes waiting between jobs, and average delivery time of 2 minutes at customer address.
Bicycles parked on the footway not kerbside during delivery or collection.
Average meal weight assumed to be 1 kg.
CO_2e vehicle emissions data per km for bicycles, mopeds and cars from DBEIS and DEFRA, 2017; European Cyclist's Federation, 2017. Bicycle g CO_2 e/km based on extra food and drink consumption of a cyclist compared to a moped, car or van driver.

Using a similar approach, Table 3 provides a comparative assessment of the GHG emissions and transport intensity (in terms of distance driven per tonne delivered and kerbside space occupancy of the vehicle) for a selection of vehicle types used in meal deliveries and various other London-based freight transport operations including other on-demand sectors of grocery and parcel deliveries, as well as general freight transport operations using rigid and articulated heavy goods vehicles (HGVs). The data required for this analysis was gathered from survey work carried out by the authors in the Freight Traffic Control 2050 project (www.ftc2050.com) and previous studies of vehicle dwell times, journey lengths and vehicle dimensions for on-demand operators and other sectors (Allen et al., 2018a; Cherrett et al., 2012), together with secondary sources of GHG emissions data for HGV operations (DBEIS and DEFRA, 2017; European Cyclist's Federation, 2017) and interviews carried out with meal delivery managers and DDs. The results indicate the comparative transport and GHG inefficiency of meal delivery compared with other forms of on-demand deliveries and general freight operations due to the transport activity being dedicated to such a small quantity of goods. The results indicated that meal deliveries are responsible for far greater distances travelled and GHG emissions per tonne delivered than on-demand delivery of groceries, parcels and general freight operations using HGVs. A meal delivered by car is responsible for approximately 1300 times the distance travelled and 200 times the GHG emissions of an articulated HGV operation per tonne delivered. In addition, the vehicles used for meal delivery emit approximately 7-80 times more GHGs per tonne of product delivered than a rigid HGV. The results indicate that meal deliveries using cars and mopeds also result in far greater kerbside space and time occupancy than the other freight transport operations and vehicle types with which they have been compared.

Table 3. GHG emissions and transport intensity of journeys taking place wholly within London

Freight sector	Vehicle type	Km travelled per tonne of product delivered	GHG emissions per tonne of product delivered (kg CO_2/tonne)	Kerb occupancy by vehicle while parked per tonne delivered (m^2hrs/tonne)
Hot meal on-demand same-day delivery	Bicycle	4,000	64	0
	Moped		340	323
	Car		716	1,620
Grocery on-demand same-day delivery	Moped	1,600	136	22
Grocery next-day delivery	Van	100	33	48
Parcel next-day delivery	Van	44	12	127
General freight operations	Rigid HGV	11	9	6
	Articulated HGV	4	3	2

Notes:
Vehicle dwell times and journey lengths for meal deliveries and other on-demand deliveries (i.e. grocery and parcel) gathered from survey work carried out in the FTC2050 project (Allen et al., 2018).
HGV data sources: vehicle kms and trip lengths in London disaggregated from DfT Continuing Survey of Road Goods Transport (CSRGT) (Allen et al., 2014), vehicle dwell times (Cherrett et al., 2012).
Assumed vehicle load weights at start of journey based on company interviews and CSRGT data: Meal delivery – 1 kg; next-day grocery delivery – 200 kg; next –day parcel delivery – 450 kg; rigid HGV - 4 tonnes; articulated HGV - 15 tonnes.
CO_2e vehicle emissions data for bicycles, mopeds, cars, vans, HGVs from DBEIS and DEFRA, 2017; European Cyclist's Federation, 2017.

Analysis was also carried out into the GHG emissions and transport intensity of having meals delivered from restaurants and takeaways on a same-day basis compared with consumers purchasing food in grocery supermarkets by car as part of their weekly shop and then cooking this food at home (Table 4). The results suggested that the combined transport and cooking energy for a meal delivery by moped or car is far greater than if a consumer purchases the ingredients themselves by car and cooks them at home (approximately 2-3 times greater in the case of a chicken meal and 2.5-4.5 times greater in the case of pizza for the specific cases studied). Meal delivery by bicycle and car-based weekly shopping and home cooking were estimated to produce similar GHG emissions. Meal delivery options are also worse than personal shopping by car in terms of distance travelled by road by a factor of 20, and in the case of deliveries by car or moped result in additional demand for kerbside space.

Table 4. Comparison of GHG emissions and transport intensity of takeaway same-day meal delivery with food purchased from shop by car and cooked at home

Meal type	Method of deriving meal	Vehicle Type	Cooking (kg CO_2e per meal)	Transport (kg CO_2e per meal)	Cooking plus transport (kg CO_2e per meal)	Vehicle km travelled per tonne delivered	Kerbside parking required at delivery point?
Pizza	Meal delivery from restaurant / takeaway	Car	0.15	0.72	0.87	4,000	Yes
		Moped	0.15	0.34	0.49	4,000	Yes
		Bicycle	0.15	0.06	0.22	4,000	No
	Personal supermarket weekly trip and cook at home in oven	Car	0.15	0.04	0.19	200	No
Chicken	Meal delivery from restaurant / takeaway	Car	0.31	0.72	1.02	4,000	Yes
		Moped	0.31	0.34	0.65	4,000	Yes
		Bicycle	0.31	0.06	0.37	4,000	No
	Personal supermarket weekly trip and cook at home in oven	Car	0.31	0.04	0.34	200	No

Notes:

Vehicle trip distances: restaurant to home and supermarket to home – both assumed to be 2km each-way trip.

Supermarket shop by car – assumed 20kg of goods purchased, 1kg of which is the meal. Meal delivery assumed to weigh 1kg.

Same vehicle CO_2e emissions factors used as in Table 2 (DBEIS and DEFRA, 2017; European Cyclist's Federation, 2017).

Oven cooking time assumptions: pizza – 10 minutes; chicken 20 minutes. Home electric oven of 2400 kWh assumed; cooking CO_2e emissions factors from DBEIS and DEFRA, 2017. Research indicates home cooking and restaurant/takeaway cooking have same energy requirements as although restaurants may cook more meals at a time, ovens are left on between cooking of meals (Calderón et al., 2018).

Wider implications for policymakers or meal home deliveries

The analysis indicates that meal deliveries are extremely intensive in terms road traffic and GHG emissions per tonne of product carried compared with other, more traditional forms of urban road freight. Considering the three vehicle types used for meal deliveries, namely bicycle, moped and car, bicycles are more efficient in terms of road space occupied, GHG emissions emitted, and kerbside space and time occupancy per tonne of product delivered compared to mopeds and cars. The latter is due to the fact that DDs do not leave their bicycles at the kerbside when making the delivery to the door. However, given the levels of pedestrian demand for pavement space in dense urban areas, and the fact that some national chain restaurants can have in excess of 70 home delivery transactions per day on average, the wheeling or leaving of bicycles on the pavement while collecting or making the final delivery could result in negative implications for pedestrians. The analysis also indicates that the combined transport and cooking energy for a meal delivery by moped or car is far greater than a consumer purchasing ingredients in person at a shop using a car and then cooking them at home. Meal delivery by bicycle compared with car-based weekly shopping and home cooking were calculated to produce similar GHG emissions.

Given the vehicle types involved and the type of delivery, meal orders are not typically considered part of freight transportation by urban policymakers. However, as this paper has demonstrated, this particular sector is growing rapidly in UK cities and others across Europe, America, and China, and is forecast to continue. Drawing on the findings presented, policymakers should discourage the use of fossil fuel-powered mopeds and cars for these meal delivery journeys. Even in suburban settings, where journey distances may be longer compared to those in a city centre, use of electrically-assisted bicycles and electric mopeds would be preferable to fossil fuel-powered vehicles. Greater capital costs, recharging and overnight storage requirements may hinder the affordability and uptake of electric bicycles and mopeds but policymakers should consider ways in which they can help support and encourage their use. Such an approach would align with current policies to promote active travel (i.e. the use of walking and cycling), which are usually directed at passenger transport, but in this case could also be promoted in terms of freight transport.

The literature has identified several important transport-related challenges that exist in the meal delivery sector which policymakers should address. These include the safety of moped and bicycle DDs, the driving behaviour of DDs and the substantial trip generation that restaurants and take-aways providing delivery services create. In terms of the road safety of bicycle and moped DDs, policymakers should consider the training schemes and road safety promotion campaigns they already have in place and whether these can be supplemented and tailored to include meal DDs. In terms of vehicle trip generation rates, policymakers need to carefully review complaints received from residents and other concerning such problems, and also to review whether the provision of delivery services from these locations is in breach of existing planning conditions imposed on the business. If such trip generation and associated problems should continue to escalate then it may become necessary for policymakers to include specific consideration of meal deliveries in their strategic reviews of planning conditions especially in terms of the provision of suitable facilities in terms of on-site toilets, litter bins, and quiet waiting areas away from residential properties for DDs to use to decrease noise and kerbside waiting.

The employment status of meal DDs has important bearings on their rights in terms of holiday pay and entitlement, sickness pay and pensions, as well as the provision of suitable in-company training. Current scrutiny of these issues in the UK and elsewhere in the meal delivery sector has the potential to have an important bearing on improving the working conditions in this field of freight transport. Such action, in terms of ensuring that DDs have worker or employed status rather than being self-employed, would also be likely to improve their access to company training schemes.

Although the findings of this paper indicate that meal deliveries are relatively inefficient compared to other forms of urban freight transport, as well as to consumers purchasing food in shops and cooking it in their own homes, at this point in time, national and urban governments have not chosen to single out particular lifestyle choices concerning consumption and delivery behaviours and subjecting these to specific regulations or taxes. This remains a future option for policymakers in the form of additional taxation imposed on operators or consumers of delivery services that are deemed harmful to wider society. Examples exist in the form of taxation on cigarettes, alcohol, sugary foods and plastic bags imposed at a national level in some countries.

Some operators have been experimenting with urban meal deliveries by pavement droid. These raise additional questions for policymakers in terms of their safety to other footway users, especially in busy locations. They also raise issues concerning the potential for vandalism and theft for operators, and are likely to remain uneconomic compared with using human low-wage labour for some time. Aerial drones offer potential for savings in journey times, road traffic levels and emissions over conventional road vehicles for meal deliveries. However, there are substantial security and safety barriers to their use for such a purpose in urban areas. Given these difficulties it seems unlikely that such delivery technologies will enter mainstream use for meal delivery in the near future.

CONCLUSIONS

Meal deliveries to homes and workplaces in cities are growing rapidly and are forecast to continue to do so. Given the relatively small numbers of such freight transport trips in the past, and the extensive use of unconventional vehicles, namely mopeds and bicycles in delivering these goods, policymakers have not traditionally paid attention to this component of urban freight transport.

Using a substantial database of 40,941 meal deliveries made by 195 couriers over 3 months in central London, this paper quantifies these impacts and discusses the transport and environmental implications of such activity along with the policy options for mitigating the negative impacts. The results suggested that the vast majority of DDs (83%) used a petrol moped, with 10% and 7% using a car and bicycle respectively. On average, 9.6 deliveries were undertaken by a rider daily, with each taking 25 minutes from pickup to delivery with an average trip length, from restaurant to customer of 2.2km (1.4 miles) and a DD travelling 41.3km (25.7 miles) in total per day. Around 49% of the riders time was found to be productive (making deliveries) during a typical day in November/December with 63% of all meals (n=22,100) being collected between 17:00 and 22:00 with lunchtime activity being substantially lower by a factor of 2.75 until 16:00.

The findings suggested that mopeds (340kg of CO2e/tonne) and cars (716kg of CO2e/tonne) emit, respectively, 5 and 11 times more GHGs per meal delivered than bicycles (64kg of CO2e/tonne), and with some national fast-food chains generating on average 70 deliveries per day, there are growing concerns around the transport intensity of these activities. With a meal delivered by car being responsible for approximately 1300 times the distance travelled and 200 times the GHG emissions of an articulated HGV operation per tonne delivered, there is a need for policy makers to promote the use of electric modes in this sector.

This paper has demonstrated that this urban freight transport sector is growing rapidly and is extremely inefficient in terms of distance travelled, GHG emissions and kerbside space and time occupancy per tonne of product delivered when carried out using mopeds and cars. The results indicate that the delivery of meals using bicycles is far less transport intensive (in terms of road and kerbside space occupancy) and should be encouraged.

Policymakers should take meal deliveries into account in their future urban freight transport strategies and policy planning. Interventions should aim to discourage the use of fossil fuel-powered mopeds and cars for these journeys, and instead promote the use of conventional and electrically-assisted bicycles. Policy makers have an important role to play in terms of ensuring adequate provision of road safety training, especially for moped and bicycle meal DDs, as well as in taking actions to help minimise the negative impacts of trip generation associated with the restaurants and takeaways from which these trips are generated.

The analysis carried out in this paper into the delivery operations and transport and GHG impacts of meal deliveries in London are, as far as the authors are aware, the first time such work has been carried out. Despite the scale of meal deliveries included in the dataset, the case study has the obvious limitations that the operational analysis was based on a single meal delivery platform working in a single city. Research into this topic would benefit from other similar studies among other companies in the same and other cities to provide evidence of how similar or different these operations and their transport and environmental impacts are in other company and city cases. It would also been helpful to be able to track the evolution of these operations over time to understand the extent to which they remain the same or change as demand and delivery activity levels grow.

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