LESSONS LEARNT FROM THE FIRST FULLY ELECTRIC BIKE SHARE SCHEME IN THE UK – A CASE STUDY OF EXETER'S CO-BIKES

Alex Thomas
Devon County Council

1. INTRODUCTION

In face of growing concerns over climate change, deteriorating urban environments and unhealthy lifestyles more attention has been placed on the role of sustainable transport alternatives. Bike share schemes (BSS) have emerged as just one such alternative, amidst a wider cultural shift which is taking place towards shared mobility (Walker, 2017). Bike hire schemes have experienced unprecedented levels of growth and diversification in recent years. Schemes are being introduced as part of the objective to increase cycling, reduce congestion, improve air quality and enhance active mobility options in our urban centres (Midgley, 2009; ITDP, 2014).

Few would disagree with the purported benefits of offering bike share schemes, they are shared, smart, and if managed correctly, sustainable. The introduction of electric bikes, commonly referred to as e-bikes, has been met with growing enthusiasm as schemes are perceived to have the potential to further bridge the gap between conventional bicycle use and motorised forms of travel. The gained utility of e-bikes solves many of the reasons people give for not cycling (distance, hills, physically strenuous, ownership), whilst offering many of the same benefits as the car (range, flexibility, rush-hour speed) (Fyhri, 2015).

Yet bike share schemes continue to split the common opinion. Schemes are stricken by issues of under usage, poor attrition rates and unsustainable revenue streams. Despite the pure density of shared bikes in operation, there is no consensus on where, why and what model of bikeshare scheme should be implemented. From the simplest of variables such as how often are the bikes used, for what purpose and by who, uncertainties surround the different models of bike-hire.

This paper reports some of the key findings of the authors Master's dissertation which provided a detailed appraisal of the United Kingdom's first fully electric city-wide model, Exeter's Co-Bikes.

Figure 1: Co-Bikes Electric (Source: https://www.co-bikes.co.uk/

2. JUSTIFICATION FOR STUDY

There are currently over 1900 traditional pedal bike programmes in operation around the world (Meddin and DeMaio, 2016) covering over 450 cities (O'Brian, 2019). The UK is following in the footsteps of pioneers of micro-mobility in Asia and North American, but this isn't to say we aren't making the same mistakes. Policy here has struggled to keep pace with market forces over the past decade, as various models of bike share continue to enter our streets. Fuelled in part by venture capitalism, are we beginning to witness traits of a boom and bust cycle within the UK bike share market?

In a race to infiltrate the UK, Chinese bike-sharing companies Ofo, obike, Urbo and Mobike flooded the market with dockless bikes, covering an impressive 617 km^2 during peak competition in July 2018. But following the withdrawal of three of the four operators, Dockless providers now cover just 136km^2 (O'Brein, 2019). Meanwhile, new dockless operators continue to enter the market despite the question marks over expense of the production and maintenance of dockless bike fleets.

Approximately 1 in 7 schemes are forced into closure before the end of their contract (Meddin, 2018). In the UK, over 14 programmes have closed their operation since 2010 with many not lasting more than 2 years. Figure 2 below provides a graphic representation of the scale of bike share schemes across Europe and the quantity of schemes which have ceased their operations (Meddin, 2018).

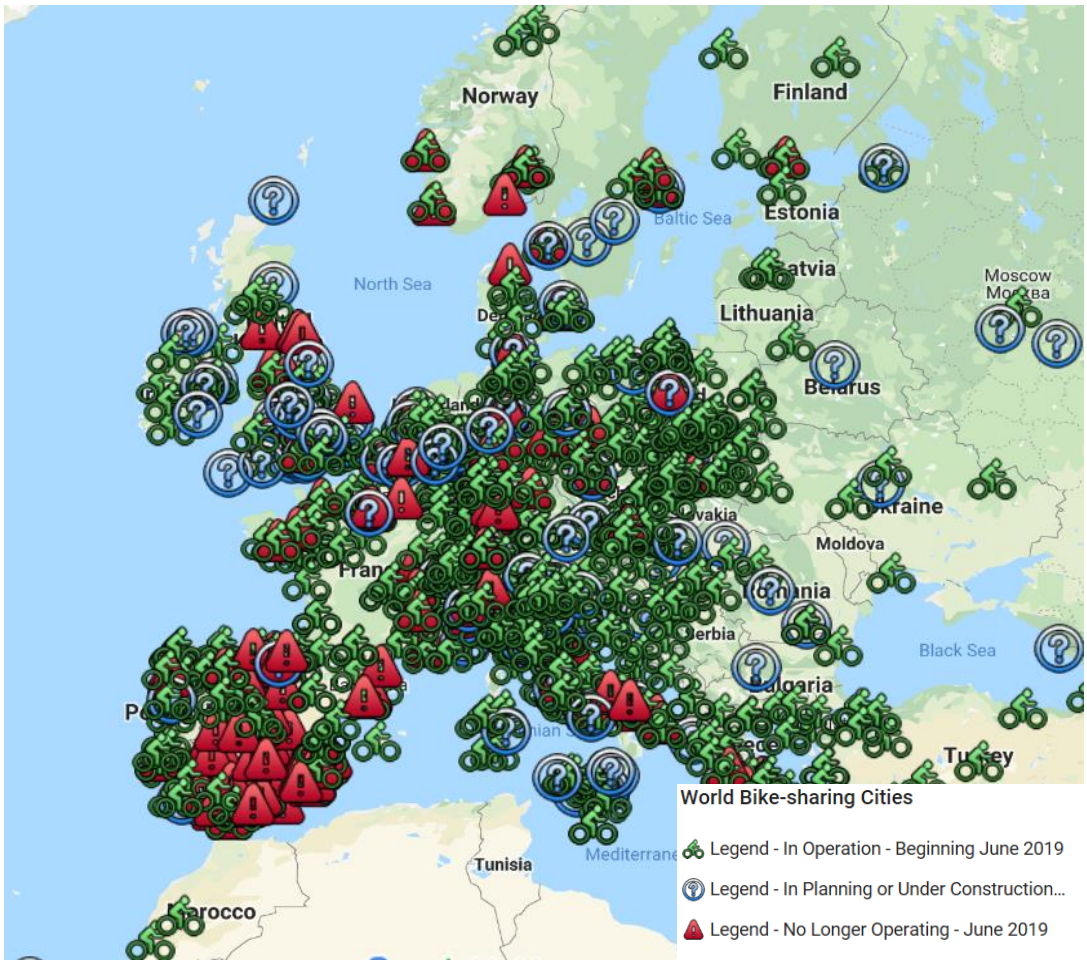

Figure 2: Bike-Sharing World Map (Meddin, 2019)

It is clear there is no one set model which works best in all jurisdictions (DeMaio, 2009). If shared bikes are to form a key component of an integrated and intelligent transport system, improved policy guidance is required. Whilst key players in the market are focusing their immediate effort on mega cities, there are question marks over what role e-bike share schemes can play in the medium to small cities in the UK. Local authorities now face an uphill challenge to maintain balance between facilitating innovation and maintaining the efficiency of the existing transport network.

2.1 E-BIKE SHARE SCHEMES

Private electric bikes represent one of the fastest growing segments of the transport market accounting for 70% of new private bike purchases (Fishman, 2012). But shared e-bikes are still considered a novelty mode in urban mobility in the UK. The main body of research has been provided by COMO, formerly known as CarPlus BikePlus, funded through the Department for Transport (DfT). The project included 11 electric bike share schemes at 16 locations, totalling 188 e-bikes spread across a variety of settings as shown below.

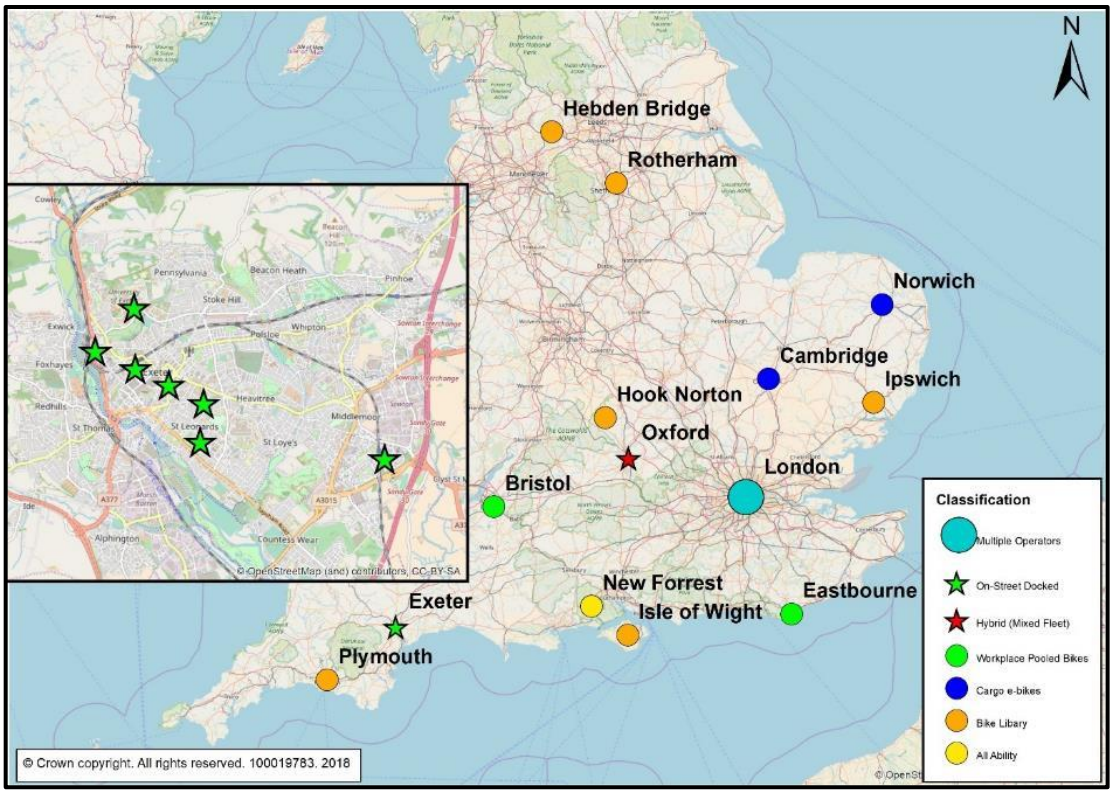

Figure 3: Como Electric Bike Share Pilot Schemes

The *Shared Electric Bike Programme Briefing* documented several encouraging findings for the emerging mode. However, findings need to be quantified further as the report is constrained by data from the launch of the schemes in spring 2016 to the end of October 2016. Following the COMO report, Oxonbikes ceased operation in Oxford. At the time of this study, *Exeter was the only docked model which provided 100% electric bikes in the United Kingdom.*

3. METHODOLOGY

The study incorporates a mixed methods approach including both primary and secondary data research. The main element of the study was the secondary data collected that looked to quantify electric bike use in Exeter and better understand the motives behind existing Co-bikes members usage. Currently, there is little evidence available from operators which interprets how their bikes operate in terms of ridership figures, trip distances, types of trips and average duration of journeys. Understanding e-bikes application will help contribute to a better-informed strategy, identifying how shared bikes can be more effectively integrated within the wider transport network.

To predict, understand and ultimately influence human behaviour moving forward (Christmas, 2009), the barriers and perceptions from non-users are of equal importance (Hampshire et al, 2012). Primary data was collected in the form of public questionnaire surveys to investigate the perceptions behind the bike share scheme, identifying the main barriers to usage and potential opportunities. This included both quantitative and qualitative elements. Figure 16 below provides a visual representation of the proposed methodology.

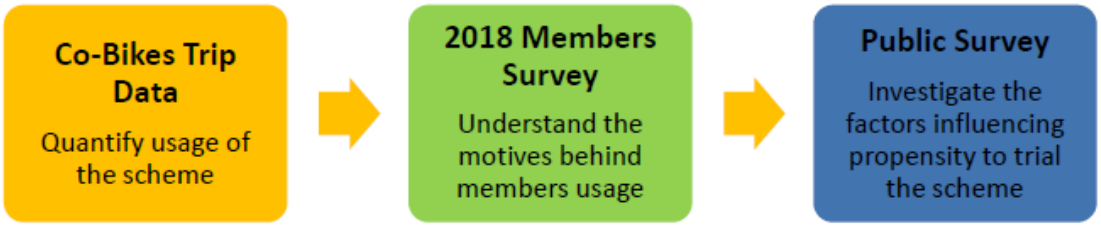

Figure 4: Data Collection Methodology

3.1 Research Questions

Through a mixed method approach, analysing primary data from public questionnaires and secondary data, provided by the operator of the bike hire scheme, the following research questions will be used to quantify electric bike usage patterns in Exeter.

1) To what extend does pricing structure influence hire period duration and trip distance?
2) To what extent do Co-bikes play a role in mitigating peak hour congestion?
3) Do shared electric bike schemes supress vehicle trip generation?
4) To what extent does proximity to a dock impact propensity to use Co-bike usage?
5) Do Co-bikes offer a more inclusive mode of transport than traditional cycling?

4. CO-BIKES CASE STUDY

Introduced in 2016, Exeter's Co-bikes are the first city-wide electric shared bike scheme in the United Kingdom. Co-bikes, supplied by German company Next Bike, are operated by *Co-Cars*. *Co-cars* are a not for profit social enterprise who run a successful car club company in Exeter. Co-bikes have a monopoly in Exeter with no competition from dock less schemes or other operators.

Figure 5: Co- Cars and Co-bike multi modal offer (Source: https://www.co-bikes.co.uk/)

Funding was awarded by the Department for Transport (DfT) to *Bike Plus* in March 2015, providing £700,000 to allocate across the partner cities (DfT, 2015). Through collaboration with Devon County Council, Co-bikes have managed to exploit opportunities for funding and expand the existing network from three docking stations in 2016 to 7 in 2018 with a total of 20 bikes.

Data	Number of Bikes	Number of Docks	Locations
Nov-16	12	3	University, Central, Digby
Mar-17	15	4	Civic Centre
Apr-17	15	5	County Hall
Dec/Jan 2018	20	7	St Davids & St Lukes

Table 1: Co Bikes implementation

Following best practise from Bike Plus, the bid and strategy targeted locations within close proximity to transport interchanges and business hubs within the city. This included docking stations enabling users to hire or return e-bikes at the following locations on a A to B hire model:

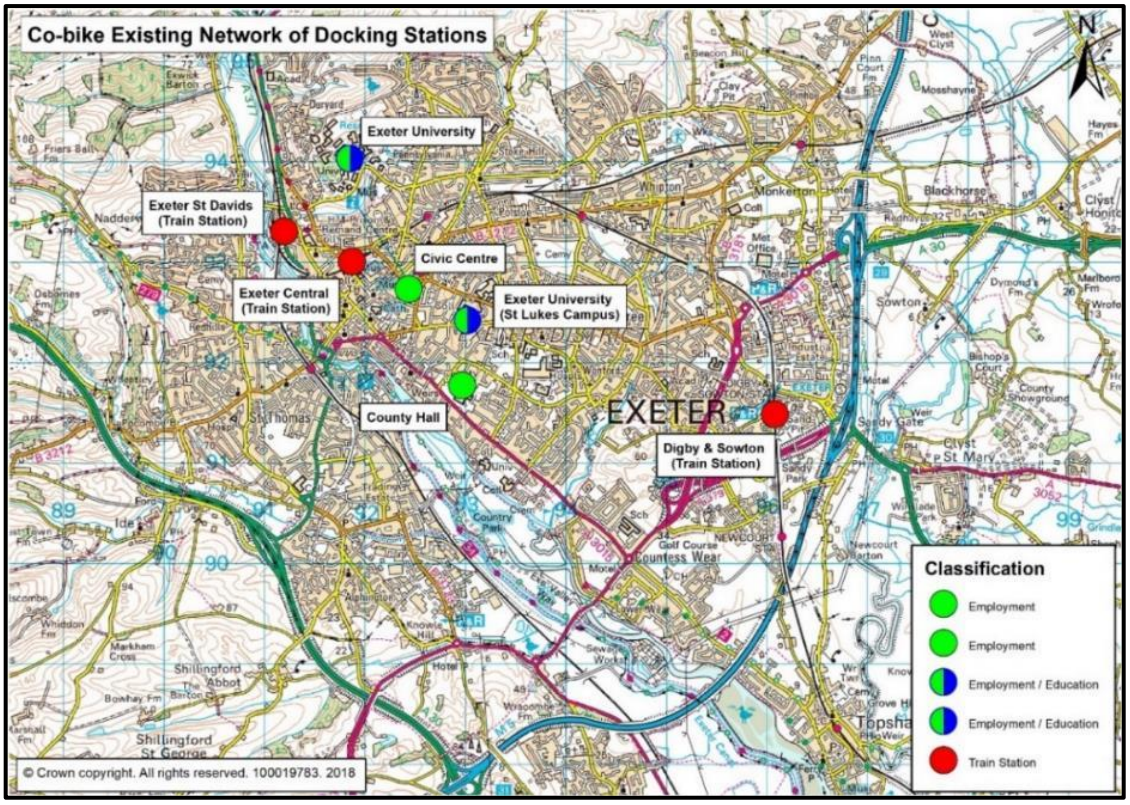

Figure 6: Co-Bike Docking Station Location & Classification

Bike Plus (2016) published the *Guide to Successful Bike Share Scheme Development*, outlining the exogeneous and endogenous factors which influence the success of a scheme. Table 2 below provides an initial feasibility test into the potential of Exeter as a bike share city.

Exogenous Factors (Bike Plus, 2016)	**Exeter**	**Evidence Case for Exeter**
Residential density	✓	Population: 117,800 (ECC, 2011) > 50 -100k guidance
Employment density	✓	87, 800 jobs within the city (ECC, 2011).
Strong tourism market	✓	400,000 plus visitors annually. Net spend > £170m (ECC, 2011)
Topography (*requiring electric bikes*)*	✓	Varied topography – Flat following the River Exe, but rising to the NE (near university) to around 248m
Cycling infrastructure	✓	Continued investment in cycling infrastructure through LSTF, Access fund and now NPIF.
Constrained vehicle travel Expensive parking Lack of attractive public transport	✓ ☒ ☒	Severe peak hour congestion on arterial routes ECC/DCC currently reviewing the city's parking strategy City is well served by Devon Metro & bus network

Climate	✓	Similar to most UK cities – shows signs of seasonality
Demographic and cycling culture	✓	Cycling modal share on the rise, fostering a young working-class population
Number of rail commuters	✓	Over 6 million trips from train stations in Exeter in 2014/15 (ORR, 2016)

Table 2: Assessment of Exeter against Bike Plus (2016) exogenous factors for success

The propensity for bike share model built by Oliver O'Brien is used as a simple tool for identifying local authorities which could have a successful bike share scheme. The model considers residential and workplace population density, the proportion of people who already commute by bicycle and a calculated vandalism rate to derive a PFB Score (O'Brien, 2019). The results of propensity for bike share model are shown below. Excluding boroughs in London, Exeter is ranked 10th highlighting its potential.

Rank (exc London)	Rank	Local Authority	Number of Operators	PFB Score	Popn. Density Rank	TTW Bike Rank	Anti-vandal Rank
1	9	Cambridge	1	416	46	1	98
2	13	Oxford	5	237	45	3	150
3	17	Portsmouth	1	95	18	8	336
4	19	Bristol	1	84	34	12	291
5	20	Gosport		83	63	5	321
6	22	Norwich	1	80	41	9	299
7	26	Worthing	1	67	56	26	199
8	27	Cheltenham	1	65	73	15	209
9	28	Brighton and	2	62	54	31	230
10	30	Exeter	1	60	65	24	214

Figure 7: Propensity for bikeshare by Local Authority (O'Brian, 2018)

5. ANALYSIS

5.1 QUANTIFYING USAGE

To quantify existing scheme usage a review, of the literature has been carried out to investigate how bike share programs perform globally. Historically, there have always been difficulties in appraising schemes utility as trip data was commercially sensitive and open source API data was largely unavailable. Providers are now beginning to acknowledge the benefits of an evidence driven strategy to maximise scheme performance. O'Brian (2019) offers the most extensive database of open source data providing the following live outputs, but unfortunately there is no separation by model of bike share.

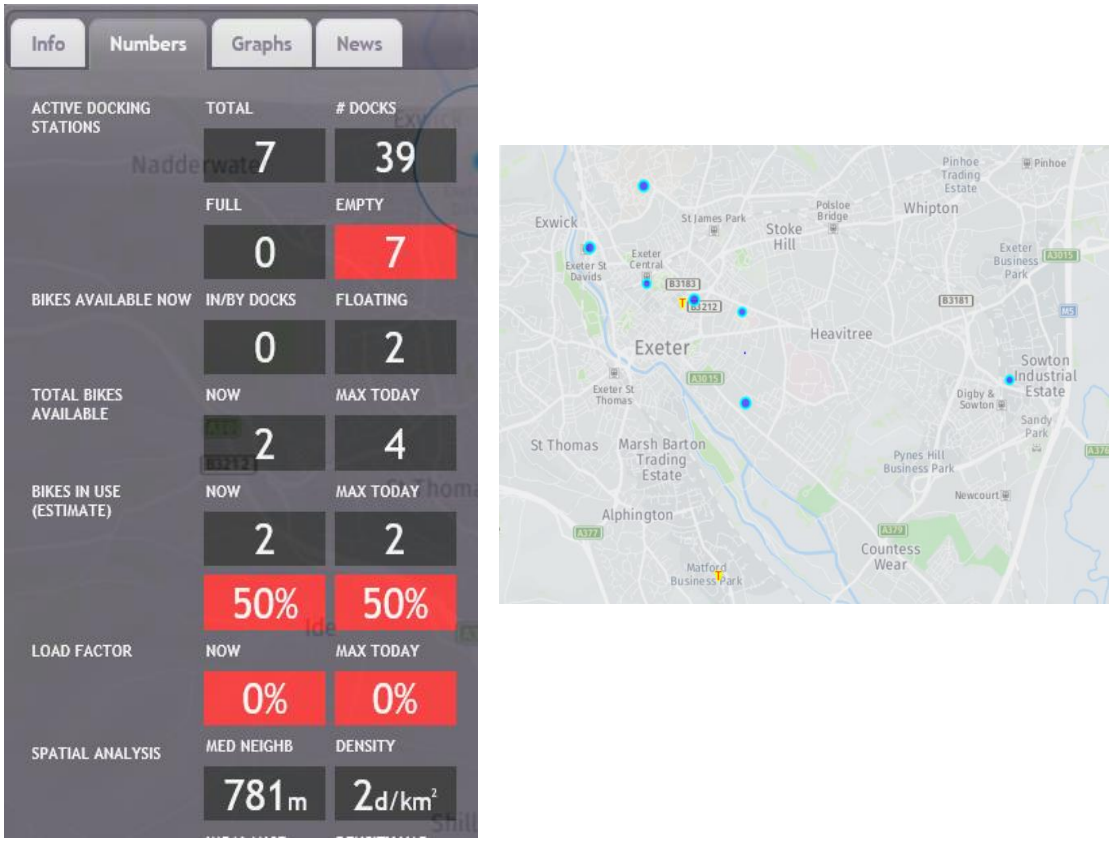

Figure 8: O'Brian Bike Share Map and Database

In comparing systems substantial differences still exist in the usage of bike share programs globally, with little evidence to support why schemes have been a success or why they have failed (Fishman et al, 2013). Trips per bike per day (t/b/d) has become the standard metric as it allows for variation in the number of bikes in a system (Fishman, 2016). Tracking and analysing the utilization of each bike helps explain three important aspects of a successful bike share: satisfaction, fleet size and revenue (O'Brian, 2019).

Globally, usage rates for traditional BSS range from around three to eight trips per bicycle per day (Fishman et al, 2011) but this is dependent on a range of factors including catchment population, number of bikes, cost of usage, location of docks amongst others (ITDP, 2018). A number of high-profile schemes show evidence of rates as low as 0.3 – 0.5 t/b/d as found by Fishman et al (2014) study.

	Brisbane (*CityCycle*)[c]	Melbourne (*MBS*)[c]	London[c]	Washington, DC[c]	New York City[a]
Bikes[b]	1800	600	8000	1800	6000
Trips (2012)	209,232	138,548	9,040,580	2,008,079	902,915
Trips per day per bike	0.3	0.6	3.1	3.0	5.2
Number of docking stations	148	50	571	191	331
Regional population	2,065,998	3,999,980	7,170,000	5,860,342	23,500,000
Annual members	1926	921	76,283	18,000	96,125
Operator	JCDecaux	Alta Bike Share	Serco	Alta Bike Share	NYC Bike Share

Figure 9: Relationship between number of bikes, members, population size and number of trips (Source: Fishman et al, 2014)

Furthermore, despite operators reporting high uptake in dockless BSS, evidence collected from O'brian (2019) shows existing dockless schemes in the UK also have very low utilisation rates. This evidence highlights the importance of specifying service level agreements, particularly when public revenue is used.

Santander Cycles	Urbo	Ofo	Mobike
~4 (summer) **~2** (winter)	**< 0.2**	No London data. **~0.7** (Sheffield)	No London data. **~0.7** (Manchester)
Based on daily statistics published in GLA data store	Based on 9,000 journeys in 9 months on 250 bikes	Based on 28,000 journeys in 6 weeks on 1000 bikes	Based on 250,000 journeys in 12 months on 1000 bikes

Figure 10:Dockless Bike Share Usage Rates (Source: [http://oobrien.com/)](http://oobrien.com/)

When investigating Co-bikes usage, it is important to recognise that the scheme launched on a skeleton network of only 12 bikes. Table 3 below provides trip rates from the introduction of the scheme in October 2016 to July 2018. The table shows that starting from a very low base, usage has been improving on a year on year basis, reaching a landmark of 1 trip per day per bike across July 2018. On peak days in July the recorded number of rentals reached 40 trips, at 2 trips per bike per day this is comparable to usage on London's Santander bikes.

	2016	**2017**	**2018**	***July 2018***
Annual Trips	286	2360	3107	*617*
Daily Trips	68	337	207	*31*
Mean No. Trips	4.2	7.0	15.0	*20*
Standard Deviation	3.2	5.2	7.2	*8.5*

Number of bikes	12	15	20	*20*
Trips per bike	0.4	0.47	0.75	***1.00***

Table 3: Historic Trip Data

Figure 11 below shows the growth in annual trips from 2017 to 2018[1]. In February 2018 Co-Bikes had 51 members paying the annual subscription (see Table 4 for pricing structure) and 624 PAYG users. Since the launch of the bike share scheme over 5000 trips have been registered.

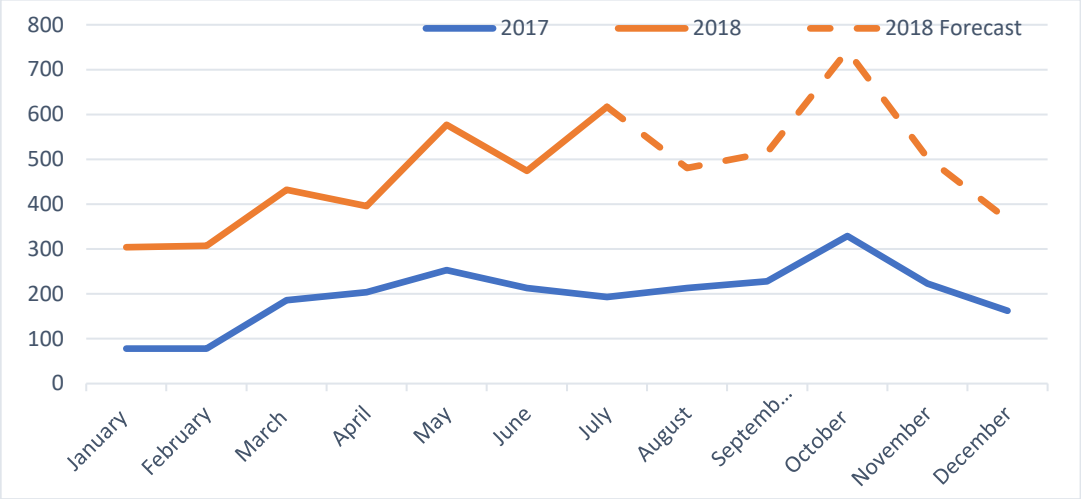

Figure 11: Co-bikes growth in annual trips

Participation rates represent a high degree of seasonality, which confirms the correlation between weather and propensity to cycle which has been highlighted in research on private bike riding (Ahmed et al, 2010). Figure 12 shows there is considerable differences in usage, both within the same system at different times of year, as well as between systems (Fishman, 2016). Recent research into Uber JUMP electric bikes in San Francisco showed usage was 78% lower on a Friday with abnormally heavy rainfall when compared with an average Friday (Rao, 2018).

[1] *July 2018 to December 2018 months have been forecast by applying the seasonality index from 2017 data to the average for 2018 up to July. Although this may result in a slight over estimate, it is anticipated that the annual number of trips will be more than double the number recorded in 2017.*

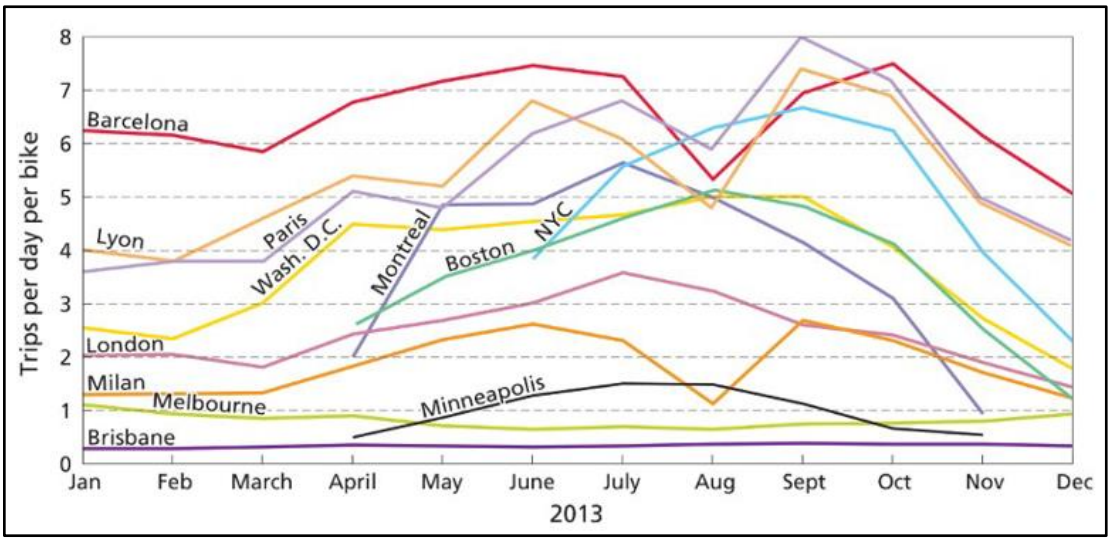

Figure 12: Traditional Bike Share Schemes Trip Rates (Fishman, 2016)

Within many projects increasing public acceptance has not yet materialized into high usage rates (Nikitas et al, 2016). This study will now investigate the range of factors influencing usage, identifying key relationships behind the shared bike scheme and the population of users and non-users in Exeter.

5.2 PRICING STRUCTURE IMPACT ON TRIP DURATION AND DISTANCE

Co-Bikes launched with a charge per 30 minutes of usage. Following an initial pilot, the structure was changed to provide members with free access for trips under 30 minutes in length. Table 4 below provides the breakdown of payment options.

Co-bikes		
Payment options	**Pay as You Ride (PAYR)**	**Annual Subscription**
Deposit	£1	
Annual subscription fee	None	£60 or £5/month
First 30 minutes of hire	£1 *(formerly £1.50)*	FREE *(formerly £0.75)*
Hire rate: per 30 minutes	£1	£0.75
Hire rate: between 10 - 24 hrs	£20	£15

Table 4: Co-bike Pricing Structure (https://www.co-bikes.co.uk/pricing/)

Data on daily trip duration supplied by the operator is provided below in Figure 13. 60% of hires are completed within half an hour and 3 out of 4 trips within an hour. This evidence poses question marks over the revenue generated from the scheme, as a high proportion of the approx. 20 trips per day will be free of charge or generate a only £1 of revenue.

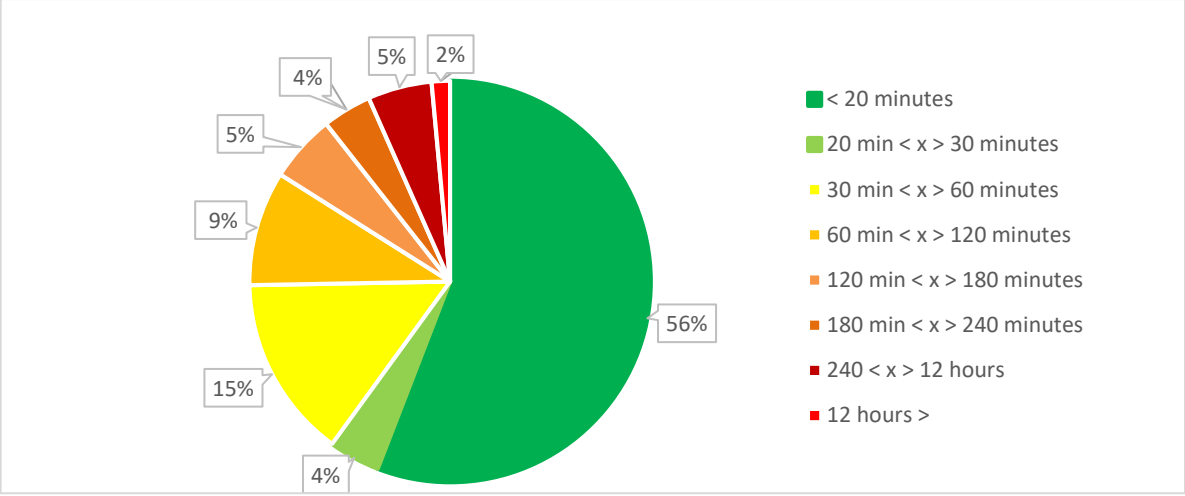

Figure 13: Hire Period Profile

The average distance travelled for A to B trips has fallen from 2.89km in 2017 to 1.44km in 2018. The figure shows that as more docking stations have been provided the proportion of A to A journeys has progressively fallen. Over the same time there has been a sharp rise in the number of A to B trips under 2km in distance.

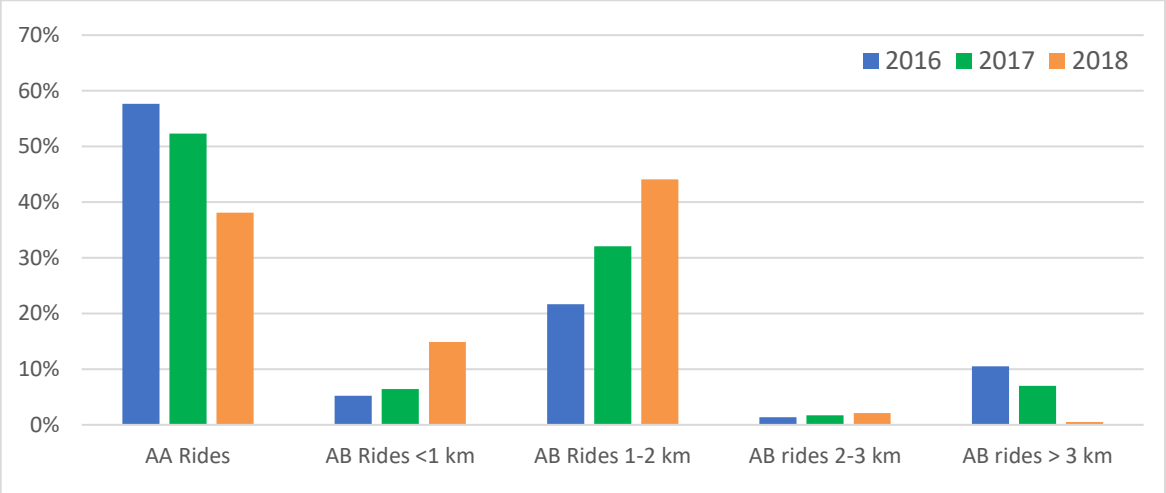

Figure 14: Trip Distance Profile

These findings stress the importance of network benefits within a city. ITDP (2018) guidance which recommends docking stations being situated in roughly uniform distance from one another should be adopted within Exeter moving forward. This study recommends docking stations to be located within a maximum of 1000m from the nearest respective docking station.

5.3 TO WHAT EXTENT DO CO-BIKES PLAY A ROLE IN MITIGATING PEAK HOUR CONGESTION?

The Co-bikes questionnaire survey asked, *"What types of trips do you do with a Co-bike?"* The results of the survey are provided below in Figure 15.

Figure 15: Members frequency of trip purpose by frequency

The figure confirms that BSS members are not particularly frequent users (Fishman, 2016). For regular users, commuting appears to be the most popular trip purpose followed by personal business. However, over 50% of users stated they never commute via Co-bike. On-street docked models' attractiveness for commuting is constrained by the location of a docking station in relation to the user's home and work address.

When comparing "How members would commute to work when they don't use a Co-Bike", the responses provide a real insight into the types of users.

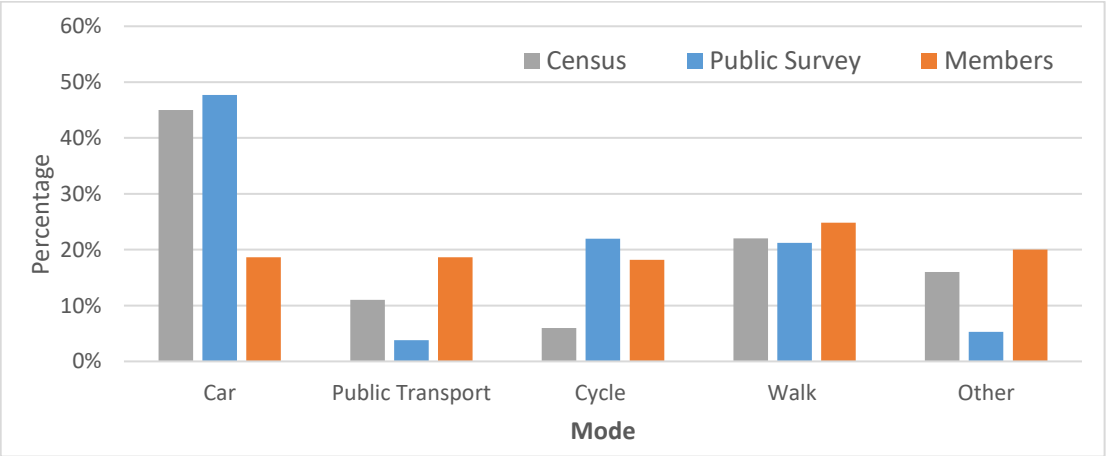

Figure 16: Travel to work mode split comparison

It is clear existing members travel patterns have a much higher proportion of trips made by sustainable modes. The figure shows only 19% of members would usually commute by car, a figure which is significantly lower than the census mode split of 45% (ONS, 2011). The early adopters of the service have revealed Co-Bikes role in mitigating peak hour congestion appears to be limited. Rather than a primary mode of commute, shared electric bikes are more attractive for one off business trips and leisure / social trips within a city.

5.4 DO SHARED ELECTRIC BIKE SHARE SCHEMES SUPRESS VEHICLE TRIP GENERATION

When trips are substituted from motorised travel, shared e-bike schemes could play an important role in the development of sustainable transport systems (Plazier et al, 2017; Dowling & Kent, 2015; Ogilvie & Goodman, 2012). Table 15 provides a breakdown of the

total number of community trips from within Exeter to destinations in Exeter, a distance which is comfortable to cover by e-bike. 15,000 vehicle trips (88%) are made for commuting trips which are less than 5km in distance. This highlights the potential for sustainable modes and shared mobility initiatives to substitute short distance internal car trips.

	Exeter – Exeter Employment Trips	
Distance	**Commuter**	**Car use**
0-2km	17,550	26%
2-5km	18,600	52%
5-10km	4,850	63%
Total	41,000	42%

Table 5: Exeter Commuting Trip Distances (ONS, 2011)

A review of traditional bike share schemes has shown programmes have resulted in a best-case scenario of 20% vehicle abstraction, as shown below in Figure 17 (Fishman, 2016). WebTAG data book V1.10.1 provides diversion factors for bus at 30% (A5.4.6) and cycle trips at 15% (A5.4.7) (Dunkerley et al, 2018).

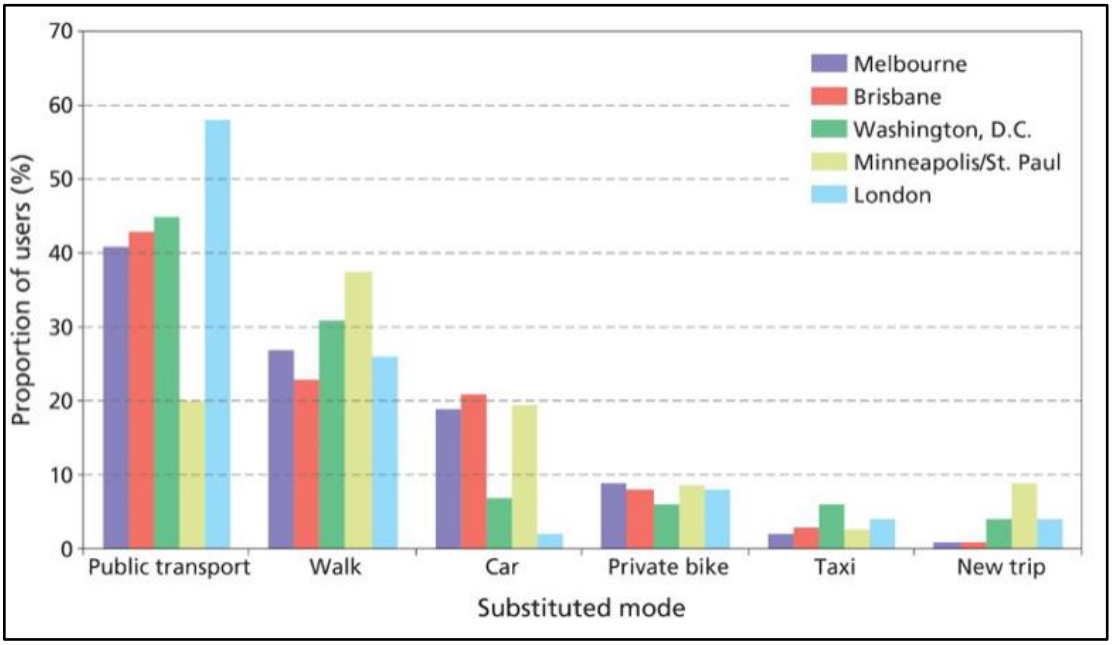

Figure 17: Modal shift from traditional bike share schemes (source: Fishman, 2016)

Figure 18 below shows the impact access to the shared bikes has had on members travel patterns 30% of respondents reported using their car less after signing up to Co-Bikes. This is comparable to Bike Plus (2016) findings that approximately 1 in 4 riders valued e-bike usage as a tool to reduce their car travel.

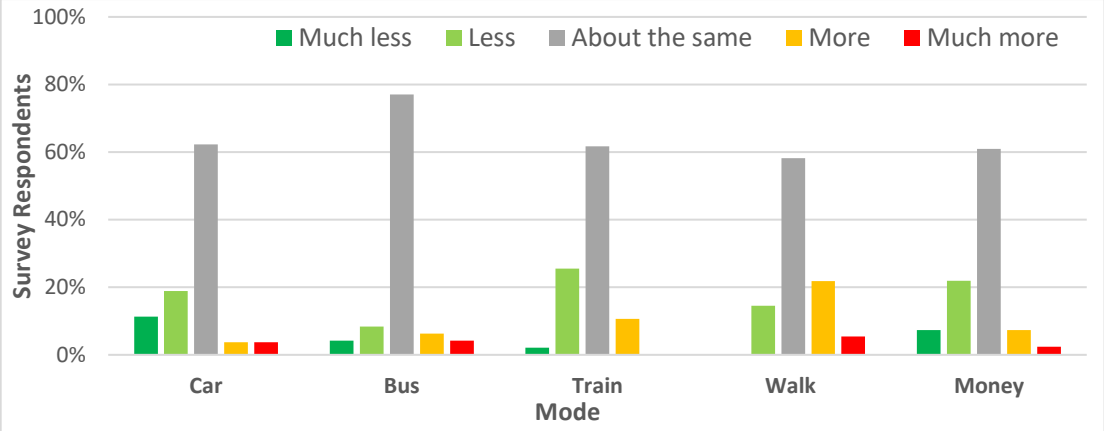

Figure 18: Trip substitution after becoming a member of Co-Bikes

5.5 TO WHAT EXTENT DOES PROXIMITY TO A DOCK IMPACT PROPENSITY TO USE CO-BIKES

Analysis was carried out using postcode data supplied by Co-Bikes 2018 members survey. The figure shows that within Exeter, the majority of members live within a 1000m catchment of a docking station (57%). 40% of the respondents of the members survey outlined no dock within close proximity to their home as their main barrier to usage.

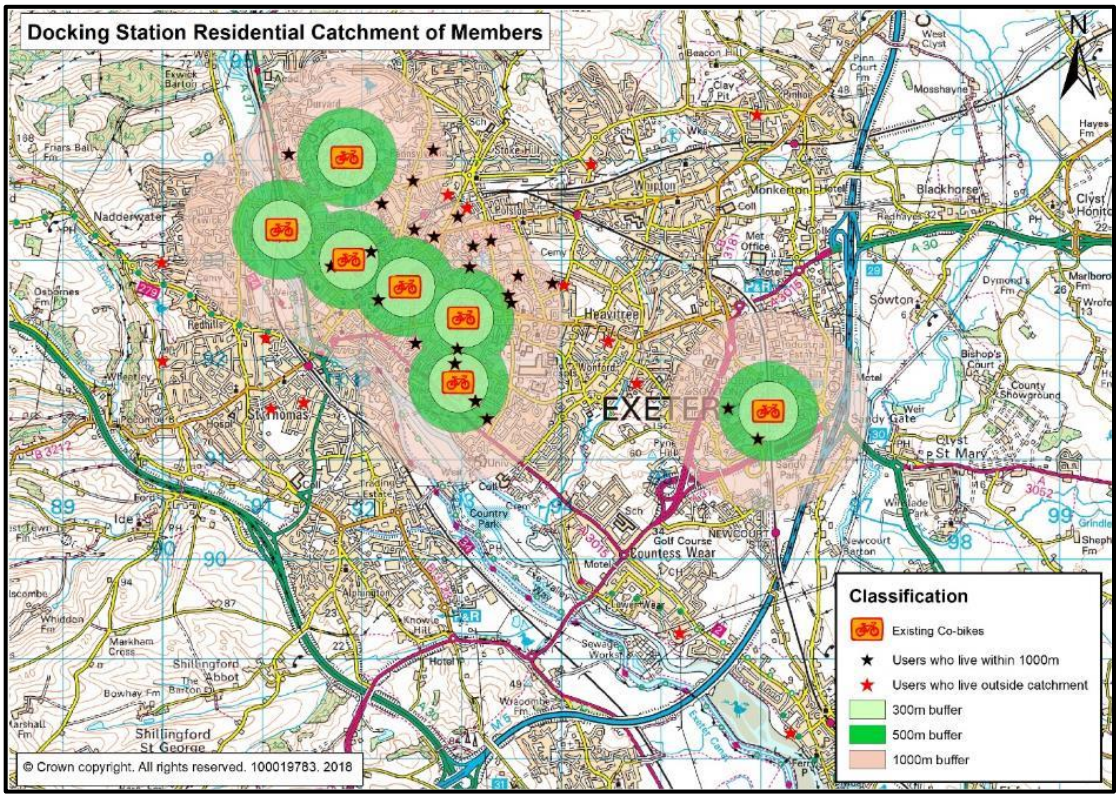

Figure 19: Relationship between dock location and members home address

In comparison, Figure 20 below shows the catchment of members workplaces. 46% of members have a docking station within 300m of their workplace and when excluding those with workplaces outside of the city's boundaries this figure rises to 65%. Of members who work in Exeter, 85% work within 1000m of a docking station.

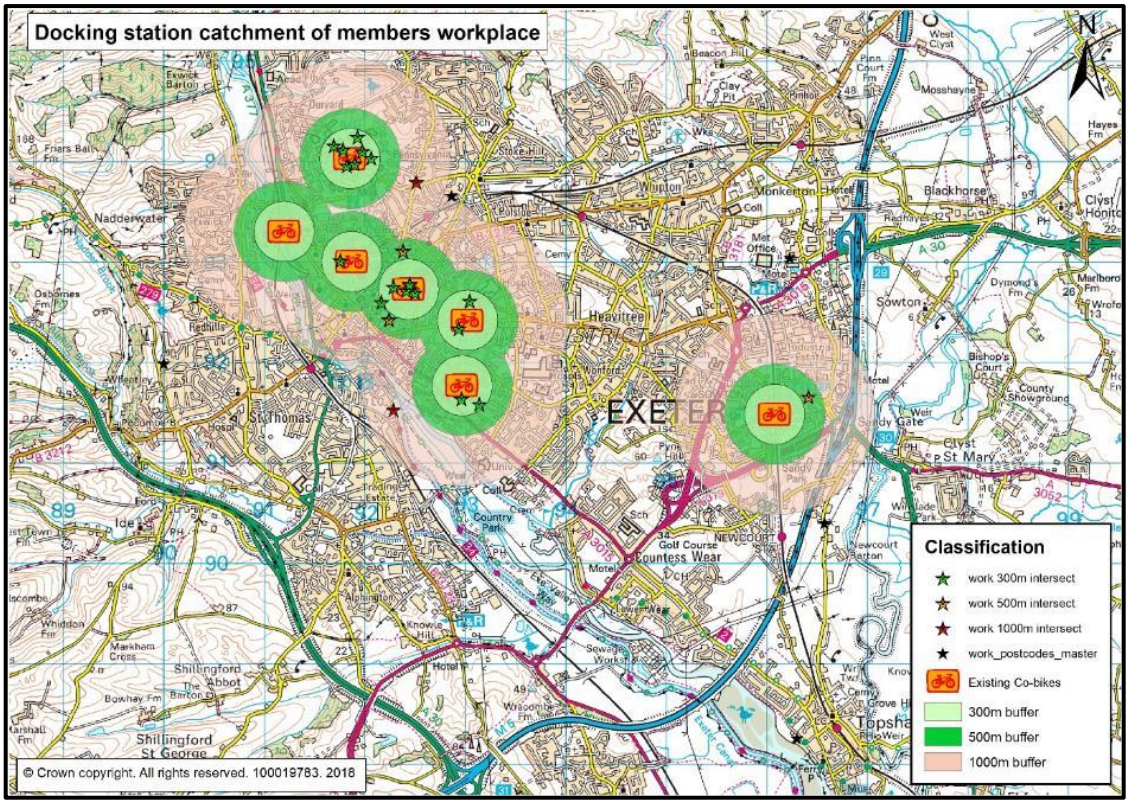

Figure 20: Relationship between dock location and members place of work

In summary, it appears the electric bike share scheme is still impacted by the first and last mile of the journey. Both surveys have stated a preference for docking stations being located closer to work or home. For the service to be attractive to a range of users docking stations need to be located at both the origin and the destination of primary movements within the city.

5.6 DO CO-BIKES OFFER A MORE INCLUSIVE MODE OF TRANSPOR THAN TRADITIONAL CYCLING?

Cycling is generally a minority activity in the UK, and participation is dominated by certain sub-groups of the population (Behrendt et al, 2014). National Travel Survey (DfT, 2017) data showed men cycle three times as many trips and four times further than women in 2016.

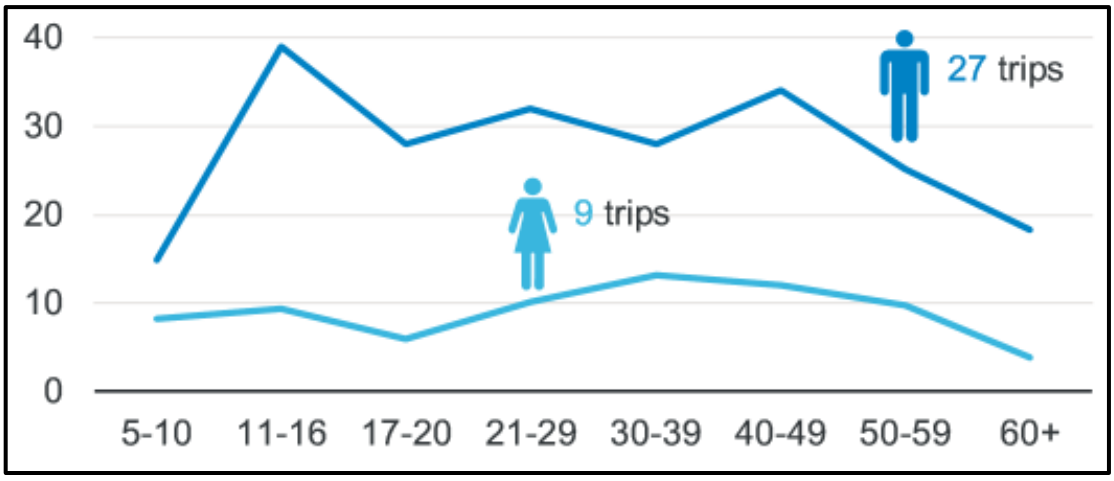

Figure 21: DfT (2018) Cycling trips per person, by age and gender, with average value for gender (Chart 9)

Whilst men use bikeshare more than women, the imbalance is not as significant as in private bike riding (Fishman, 2016). Of the 74 respondents within the Co-bikes members survey, 62% were male. This is slightly higher than the average of 55% which was recorded across the 11 electric bike share projects (Bike Plus, 2016), but is still considerably lower than the 75% for traditional cycling (DfT, 2017). These findings were strengthened by the public survey of non-users, which found no significant difference in the proportion of male and females who would consider trialling the scheme. Given females under representation as cyclists (Garrard, 2003), growth in female ridership on e-bikes could have a multiplier effect on the wider cycling gender split, contributing to normalising cycling as a mode of travel (Goodman et al, 2014).

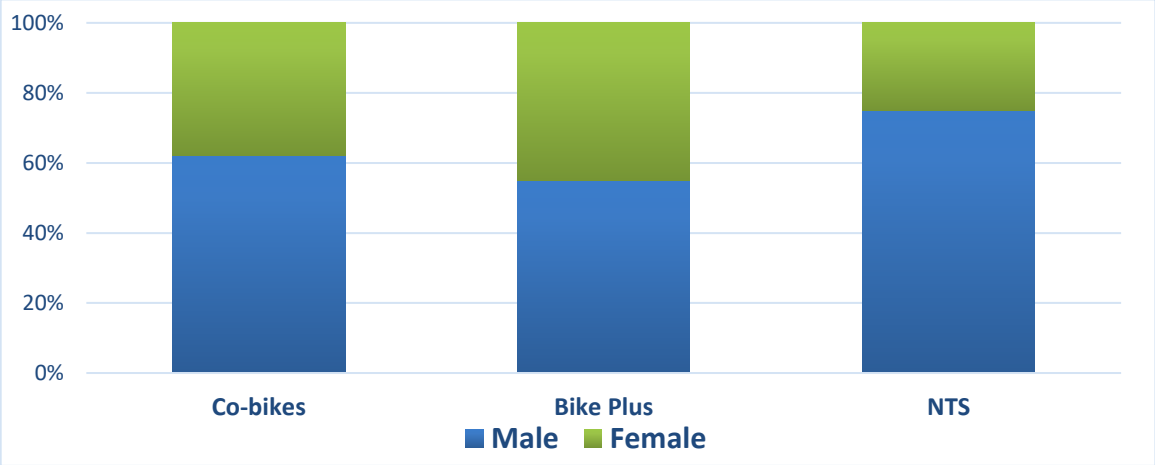

Figure 22: E-bike Impact on Gender Split

Within the public survey each respondent was questioned if they would be willing to trial a Co-bike. Encouragingly 51% of respondents stated they would consider using Co-bikes in the future, and a further 36% stated "maybe". Only 13% of respondents stated "No". From this question, it was possible to interpret how travel patterns, car ownership, cycle ownership, age, gender and stated barriers influence the participants propensity to use the scheme in the future. The Pearson Chi^2 test of homogeneity has been used for each dependent variable. The results of the tests are summarised below.

Dependent Variable	Significant
Gender	☒
Age	✓
Cycle ownership	✓
Car ownership	✓
Existing travel patterns	✓
Stated barriers	✓

Table 6: Chi Squared Results for test of homogeneity between variables influencing the propensity to trial the scheme

Evidence shows for both genders, the proportion who stated “no” to trialling the bikes increased with age.

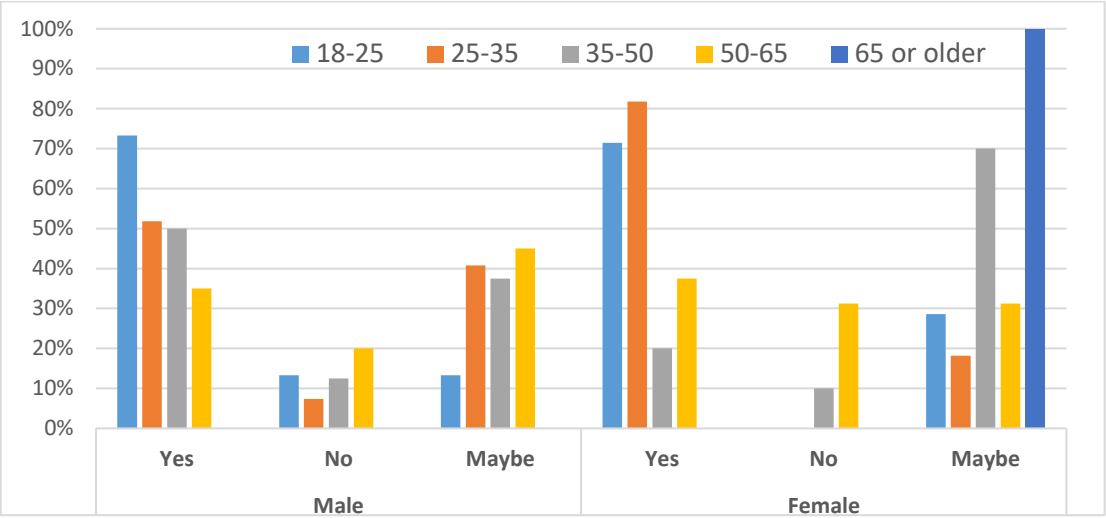

Figure 23: Demographic Impact on propensity to trial the scheme

Existing travel patterns, car ownership and cycle ownership statistics all point towards Co-bikes being most attractive for users who already travel sustainably. Once users have trialled the scheme, usage satisfaction is very high. This stresses the importance of the initial trial. The aim for Co-bikes and the local authority is to implement key measures which are inducive to attracting usage from the near 40% who stated “maybe” to trialling the service.

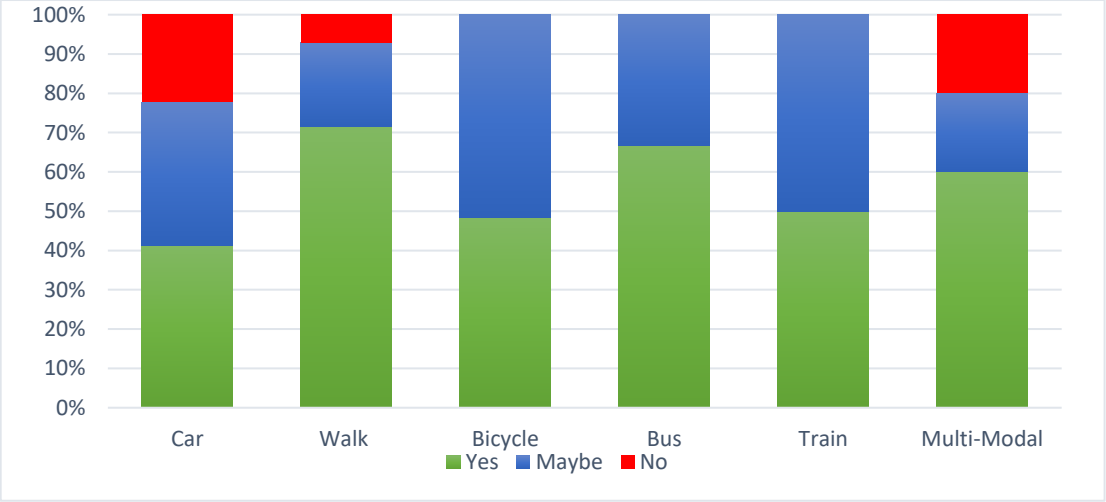

Figure 24: Existing travel patterns impact on willingness to try Co-bikes in the future

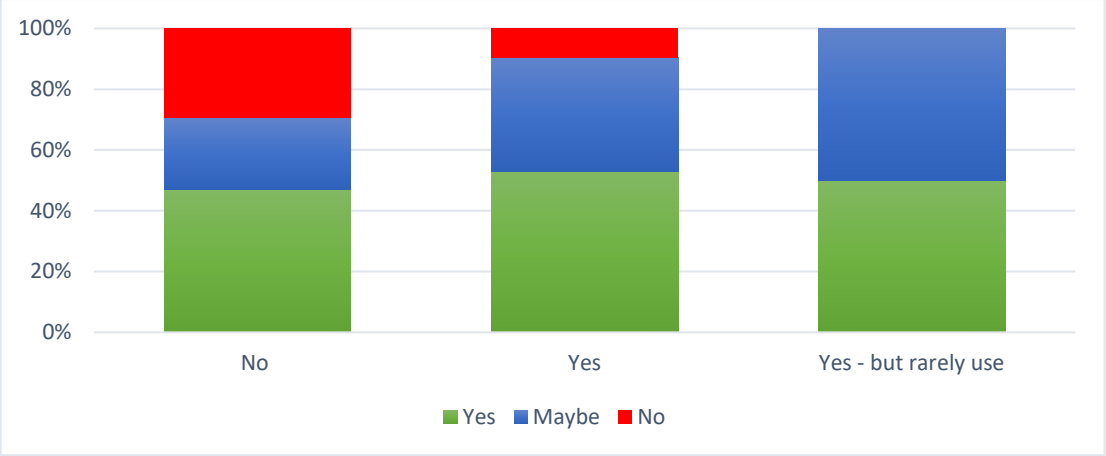

Figure 25: Bicycle ownership impact on willingness to try Co-bikes in the future

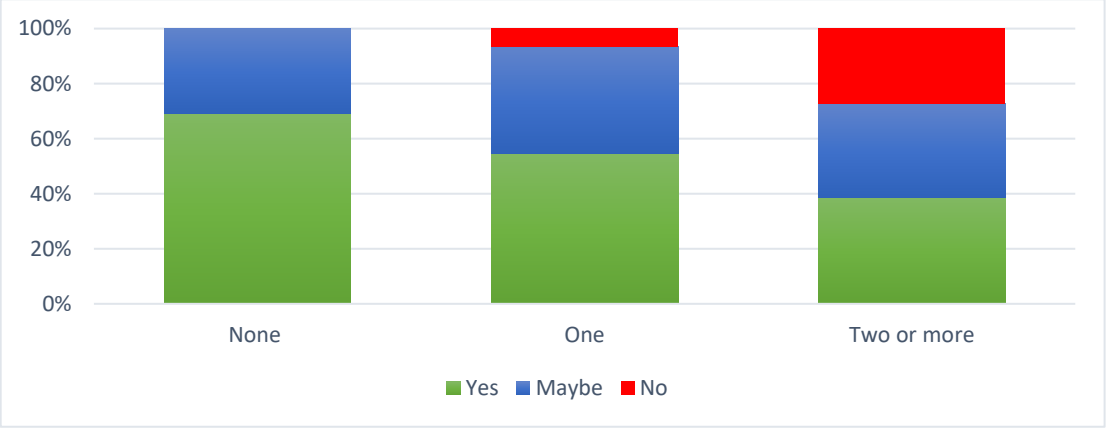

Figure 26: Car ownership impact on willingness to try Co-bikes in the future

5.7 SUMMARY OF LESSONS LEARNT FROM CO-BIKES MEMBERS

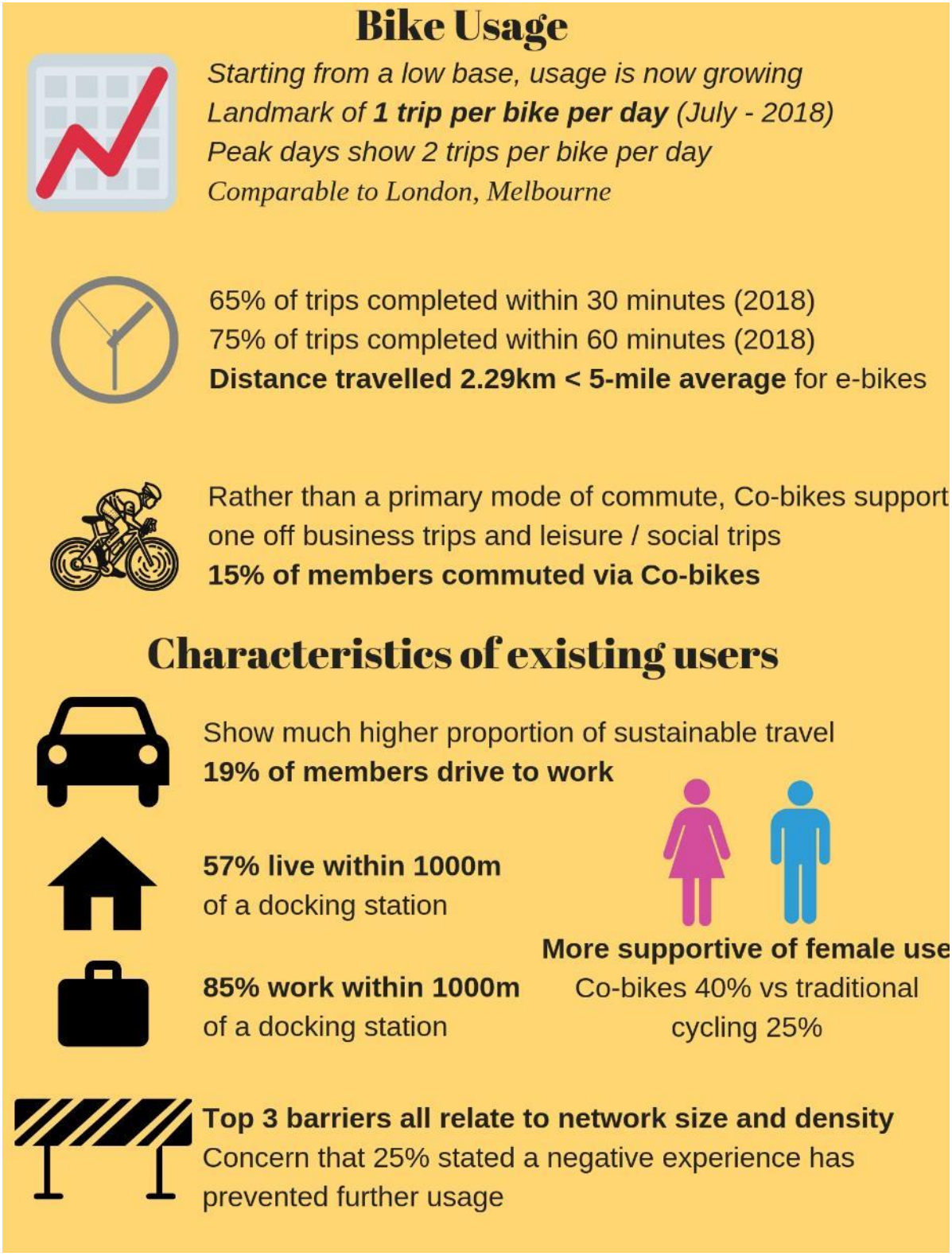

Figure 27: Lessons learnt from existing members of Co-bikes

5.8 SUMMARY OF LESSONS LEARNT FROM THE PUBLIC

Age	Proportion who stated they would never trial Co-bikes increases with age.
	Opportunity to increase the proportion of young working females travelling by bicycle.
Existing Travel Patterns	Correlation between sustainable modes and propensity to trial e-bikes
	Of respondents who currently drive to work, only 41% would consider trialing Co-bikes
Car Ownership	The likelihood of trialing Co-bikes decreases with car ownership
	40% of participants with access to two or more cars stated they have no intention of trialling the scheme.
Bicycle Ownership	30% of users who don't own a bicycle will not consider trialing Co-bikes
	10% of bicycle owners feel there is no need to use Co-bikes as they prefer using their own bicycle
Barriers to usage	Similar to members of Co-bikes, no docking station within close proximity of home or work was cited as the most significant barrier. A further 17% stated insufficient network size.
	Lack of understanding on how to access and use the service cited by 40% of participants as their main barrier
	Registration and access to bikes accounted for 16% of responses.
Stated Preference for the scheme	More bikes at new locations (82%), improved access and user interface (61%) and improved promotion and training (46%) are perceived to be the most important factors to increasing cycle up-take.

Table 7: Summary of lessons learnt from the public

6. CONCLUSION

Little is known about e-bikes application into shared travel and how effective schemes can be as a measure for local authorities to adopt. Cities need to continue to take a more proactive role in introducing innovation. Our streets are public space, and with the rise of micro-mobility options which will seek to share these spaces, local authorities require more guidance on how they can best optimise the allocation of space.

This study has documented the purported benefits and shown why many believe schemes can be a positive mobility option to introduce within urban centres. Evidence for a phased strategy of delivery can be quantified by Co-bikes growth in usage and membership data. Operating with 20 bikes spread across 7 docking stations, usage is comparable to schemes implemented on a much larger scheme, achieving two trips per day per bike on peak days. Co-bikes support ad-hoc business and social / leisure trips within the city, whilst their attractiveness as a primary mode of commute is constrained by the operational scale and density of the network. Pricing structure has been found to influence trip distance and hire period length, whilst membership is strongly linked to access to a docking station.

As Co-Bikes expands to up 100 bikes in 2019/20, analysis will be required to investigate the correlation between network size and bike usage, further exploring the relationship between docking station location and e-bike utility, redistribution and trip purpose. This work could be a source of guidance to future electric bike schemes, highlighting the motives behind membership and the barriers which discourage usage.

Ongoing close attention on the dynamics and changes of the bike sharing industry will continue to be revealing.

7. REFERENCES

Ahmed, F., Rose, G., & Jacob, C. (2010). Impact of weather on commuter cyclist behaviour and implications for climate change adaptation. Paper presented at the Australasian Transport Research Forum, Canberra.

Behrendt F, Cairns S, Raffo D (2014) Electrically-assisted bikes. Response to the call for evidence on government measures to support uptake of ultra-low emission vehicles from 2015-2020

Bike Plus (2016) Bike Share Success Factors: A guide to the types of locations where bike share can flourish. Available from: https://como.org.uk/wp-content/uploads/2018/06/Factors-for-Successful-Bike-Share-Schemes-feb-2016.pdf (*Accessed 02/08/2018)*

Bike Plus (2016) Shared Electric Bike Programme Report: findings and recommendations from eleven shared electric bike projects. Available from: https://como.org.uk/wp-content/uploads/2018/05/Shared-Electric-Bike-Programme-Final-Report.pdf (*Accessed 05/07/2018)*

Bike Plus (2016) The Bike Plus Guide to Successful Bike Share Development. Available from: https://como.org.uk/wp-content/uploads/2018/06/Bike-Share-Procurement-Guidance-HI-RES.compressed.pdf *(Accessed 06/08/2018)*

Christmas, S. (2009) Nine Big Questions about Behaviour Change. DfT. London.

Como (2018) Public Bike Share Procurement Guidance 2018. Available from: https://como.org.uk/wp-content/uploads/2018/05/CoMoUK-Public-Bike-Share-Procurement-Guidance-2018.pdf *(Accessed 22/08/2018)*

DeMaio, P., (2009) Bike-sharing: History, impacts, models of provision, and future. *Journal of public transportation*, *12*(4), p.3.

Devon County Council (2018) Co-bikes expands with £340,000 of new stations rubberstamped, Available from: https://www.devonnewscentre.info/co-bikes-expands-with-340000-of-new-stations-rubberstamped/ (Accessed 14/07/2018)

DfT (2015) Cycling revolution goes electric. Available from: https://www.gov.uk/government/news/cycling-revolution-goes-electric (Accessed 05/04/2018)

DfT (2017) National Travel Survey: England 2017.

DfT (2018) Walking and Cycling Statistics, England: 2016

Dowling, R. and Kent, J., (2015) Practice and public–private partnerships in sustainable transport governance: The case of car sharing in Sydney, Australia. *Transport Policy*, *40*, pp.58-64.

Dill, J., and Rose, G. (2012). Electric bikes and transportation policy, Transportation Research Record, 2314, pp. 1–6.

Dunkerley et al (2018) 'Bus fare and journey time elasticities and diversion factors for all modes', carried out by RAND on behalf of DfT.

Exeter City Council (2018) Exeter Economy in Numbers. Available from: https://exeter.gov.uk/business/relocating-to-exeter/exeter-economy-in-numbers/ (Accessed 01/08/2018)

Fishman, E., Ker, I., Garrard, J. and Litman, T. (2011) Cost and health benefit of active transport in Queensland produced for Queensland Government, Brisbane: Institute for Sensible Transport.

Fishman, E., Washington, S., & Haworth, N. (2012). Understanding the fear of bicycle riding in Australia. Journal of the Australasian College of Road Safety, 23(3), 19–27.

Fishman E, Washington S and Haworth N (2013) Bike share: a synthesis of the literature. Transport Reviews 33(2): 148–165

Fishman, E. (2014). Bikeshare: Barriers, facilitators and impacts on car use (PhD thesis by publication). Queensland University of Technology, Brisbane.

Fishman E, Washington S and Haworth N (2014) Bikeshare's impact on car use: evidence from the United States, Great Britain and Australia. Transportation Research Part D: Transport and Environment 31: 13

Fishman, E., Washington, S., Haworth, N. and Watson, A., (2015) Factors influencing bike share membership: An analysis of Melbourne and Brisbane. *Transportation research part A: policy and practice*, *71*, pp.17-30.

Fishman, E. and Cherry, C., (2016) E-bikes in the Mainstream: Reviewing a Decade of Research. *Transport Reviews*, *36*(1), pp.72-91.

Fyfe, M., (2010) A new helmet to bring riders into the fold. *State Politics, The Age (Melbourne, Vic.)*, p.1.

Fyhri, A. and Fearnley, N., (2015) Effects of e-bikes on bicycle use and mode share. *Transportation Research Part D: Transport and Environment*, *36*, pp.45-52.

Garrard, J., (2003) Healthy revolutions: promoting cycling among women. *Health Promotion Journal of Australia*, *14*(3), pp.213-215.

Goodman, A., Green, J. & Woodcock, J. (2014) The role of bicycle sharing systems in normalising the image of cycling: An observational study of London cyclists. Journal of Transport & Health, 1 (1), 5-8.

Goodwin, P., Schwanen, T., Clark, B., Jain, J., Melia, S., Middleton, J., Plyushteva, A., Ricci, M., Santos, G. and Stokes, G. (2018). Young People's Travel – What's Changed and Why? Review and Analysis. Report to Department for Transport. UWE Bristol, UK.

Hampshire, R.C. and Marla, L., (2012) An analysis of bike sharing usage: Explaining trip generation and attraction from observed demand. In *91st Annual meeting of the transportation research board, Washington, DC* (pp. 12-2099).

Institute for Transportation & Development Policy (2014) Bikeshare Planning Guide. Available from: https://www.itdp.org/wp-content/uploads/2014/07/ITDP_Bike_Share_Planning_Guide.pdf (Accessed 02/08/2018)

Institute for Transportation & Development Policy (2018) Bikeshare Planning Guide. Available from: https://bikeshare.itdp.org/ (Accessed 25/07/2018)

Meddin, R. (2014). Bikeshare cities 1998–2013: Dataset provided to author

Meddin, R. (2015). The Bike Sharing World - 2014 -Year End Data. [Online] http://bikesharing.blogspot.co.uk/2015/01/the-bike-sharing-world-2014-year-end.html [Accessed 22/03/2018].

Meddin, R. and DeMaio, P., (2016) The bike-sharing world map. *[Online] Available from:* http://www bikesharingworld.com [Accessed 22/07/2018].

Meddin, R and DeMaio, P (2018) The bike-sharing world map. *Online] Available from:* http://www bikesharingworld.com [Accessed 22/07/2018].

Midgley, P., (2009) The role of smart bike-sharing systems in urban mobility. *Journeys*, *2*(1), pp.23-31.

Midgley, P., (2011) Bicycle-sharing schemes: enhancing sustainable mobility in urban areas. *United Nations, Department of Economic and Social Affairs*, pp.1-12.

Nikitas, A., Wallgren, P. and Rexfelt, O., (2016) June. The paradox of public acceptance of bike sharing in Gothenburg. In *Proceedings of the Institution of Civil Engineers-Engineering Sustainability* (Vol. 169, No. 3, pp. 101-113). ICE Publishing.

Nikitas, A (2017) Bike-sharing fiascoes and how to avoid them – an expert's guide. Available from: https://theconversation.com/bike-sharing-fiascoes-and-how-to-avoid-them-an-experts-guide-84926 [Accessed 22/07/2018].

O'Brian, O (2018) Where Might Bikeshare Succeed in Great Britain? Available from: http://oobrien.com/2018/04/where-might-bikeshare-succeed-in-great-britain/ *(Accessed 03/02/2019)*

O'Brian, O (2019) Bike Share Map. Available from: http://oobrien.com/bikesharemap/ *(Accessed 03/02/2019)*

O'Brian, O (2019) Docless Bikeshare in London: Part 2. Available from: http://oobrien.com/ *(Accessed 03/02/2019)*

Office for National Statistics (2011) Table KS101EW - Usual resident population, total population. (MSOA level). Available from: https://www.nomisweb.co.uk/census/2011/ks101ew *(Accessed 24/07/2018)*

Office for National Statistics (2011) Table WU03EW - Location of usual residence and place of work by method of travel to work (MSOA level). Available from: https://www.nomisweb.co.uk/census/2011/wu03ew *(Accessed 24/07/2018)*

Ogilvie, F. and Goodman, A., (2012) Inequalities in usage of a public bicycle sharing scheme: socio-demographic predictors of uptake and usage of the London (UK) cycle hire scheme. *Preventive medicine*, *55*(1), pp.40-45.

Plazier, P.A., Weitkamp, G. and van den Berg, A.E., (2017) "Cycling was never so easy!" An analysis of e-bike commuters' motives, travel behaviour and experiences using GPS-tracking and interviews. *Journal of transport geography*, *65*, pp.25-34.

Popovich, N., Gordon, E., Shao, Z., Xing, Y., Wang, Y., and Handy, S. (2014). Experiences of electric bicycle users in the Sacramento, California area, Travel Behaviour and Society, 1 (2), pp. 37–44.

Rao (2018) Understanding multimodality : An analysis of early jump users, Available from: https://medium.com/uber-under-the-hood/understanding-multimodality-an-analysis-of-early-jump-users-4a35d647b7e6 *(Accessed 22/07/2018)*

Transport for London (2018) Electric Bikes. Available from: https://tfl.gov.uk/modes/cycling/cycling-in-london/electric-bikes *(Accessed 22/01/2018)*

Walker, R (2017) Bike-sharing pedaling towards becoming a British way of life, The Guardian. Available from: https://www.theguardian.com/uk-news/2017/nov/10/bike-sharing-british-way-of-life-schemes-double *(Accessed 24/07/2018)*

Weinert, J., Ma, C. and Cherry, C., (2007) The transition to electric bikes in China: history and key reasons for rapid growth. *Transportation*, *34*(3), pp.301-318.