Transportation Research Part A 100 (2017) 152–161

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Examining usage patterns of a bike-sharing scheme in a medium sized city

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ARTICLE INFO

Article history:
Received 16 May 2016
Received in revised form 4 November 2016
Accepted 21 April 2017
Available online 28 April 2017

ABSTRACT

Bike-sharing is one of the fastest growing new modes of transport in the world, with more and more schemes opening every year. This paper examines the trends in a bike-sharing scheme that has been in operation in Cork since 2014. While many studies exist on how bike-sharing schemes are changing mobility in cities across the globe, few studies have looked at the dynamics of these schemes in smaller cities. One of the motivations in looking at a small city like Cork is to determine if smaller cites derive benefits from bike-sharing schemes and can bike-sharing schemes provide a prominent role in these cities. This research found that in a small, compact city like Cork, average trip times recorded are short with regular uses displaying habitual trip patterns. This includes using the same bike stations and following similar routes on a daily or weekly basis. The findings also suggest weather has an impact upon usage, with longer trips more likely during better weather conditions. The findings of the paper provide insights to the dynamics of usage of a smaller bike-sharing scheme and results on how bike-sharing is offering citizens a new transport alternative.

1. Introduction

Cork Bikes opened in December 2014 with 31 stations and 330 bikes across Cork city. The scheme covers the city servicing all the main trip attractors in the city center including bus and rail stations and University College Cork (UCC) (See Fig. 1). Cork is the second largest city in the Republic of Ireland and had a population of approximately 120,000 in 2011 (CSO, 2011). Table 1 details the modal split of trips to work or university in Cork City in 2011. This data is taken from the 2011 census of Ireland. The results show that in Cork City that driving to work alone has the largest modal share (45%) followed by walking (27%). Cycling has a smaller modal share (3%) however cycling in the city, as with the rest of Ireland, is increasing (Caulfield, 2014). The introduction of the bike scheme in Cork is seen as a policy intervention to increase cycling in the city (National Transport Authority, 2016).

Bike sharing schemes have grown in popularity across the globe in recent years. Much research has been conducted on bike schemes in larger cities but little has been conducted on schemes in smaller cities like Cork. Table 2 details 48 bike-sharing schemes globally with 400 or less bicycles in their current schemes (Bikesharingworld, 2016). The majority of bike-sharing schemes of a similar size to Cork also have a similar population. Given the number of schemes globally of a similar size, it is important to examine how these schemes work and how users interact with these schemes.

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http://dx.doi.org/10.1016/j.tra.2017.04.023
0965-8564/

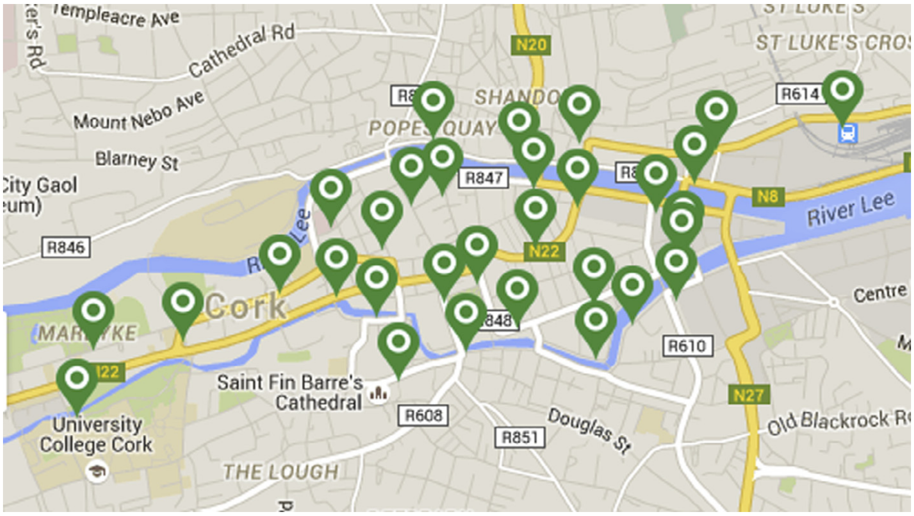

Fig. 1. Map of the Cork Bikes scheme.. Source: Cork Bikes (2016)

Table 1
Mode share in Cork City (those employed and attending University).

Mode	N	%	Average travel time (minutes)	Standard Deviation of travel time
Walking	13,645	27	17	11.12
Cycling	1701	3	16	9.65
Bus	4601	9	30	17.55
Rail	182	0	47	32.41
Motor cycle	296	1	17	12.33
Driver – alone	22,330	45	20	14.29
Drive – passenger	3128	6	18	11.72
Van	1458	3	24	18.53
Other means	130	0	28	24.61
Work from home	731	1	–	–
Not stated	1790	4	–	–
Total	49,992	100	–	–

The research objective of this paper is to examine the trends of usage of a bike-sharing scheme in a small city. The research seeks to determine if in a small city bike-sharing can play a valuable role. Specifically the research looks at how several factors such as weather conditions, routes, distance travelled and frequency of usage impact upon trip time on the bike-sharing scheme. The research adds to the body of rapidly growing work in this field as it considers the usage of a bike-sharing scheme in a small city.

2. Literature review

Numerous concerns regarding the growth of the road transportation sector and climate change have led to the developed interest in sustainable transportation alternatives, and bike-sharing (i.e. the shared use of a bicycle fleet which is accessible to the public and serves as a form of public transportation (Parkes et al., 2013)) is emerging as a prominent strategy to assist in addressing concerns such as the usage of clean fuels, transportation demand management, and land use and transportation connection (Shaheen et al., 2010). As of June 2014, public bike-sharing programmes were incorporated into 712 cities across five continents, comprising approximately 806,200 bicycles at 37,500 stations (Shaheen et al., 2014). Bike-sharing schemes have evolved over the years, initially consisting of free-to-use bike systems and followed by coin-deposit systems, and the majority of today's bike-sharing schemes are IT-based systems, with some cities incorporating additional functionalities such as demand-responsive and multi-modal systems with real-time information (Shaheen et al., 2010).

Bikes-haring schemes are associated with environmental benefits through the diminished usage of motor vehicles and the associated reduction in fuel use and traffic congestion. In addition to these environmental benefits there have also been numerous social benefits reported through the usage of bikes-haring schemes. The American Public Health Association found that the implementation of a public bicycle share programme can lead to greater likelihood of cycling amongst persons living in areas where bike-sharing schemes are available (Fuller et al., 2013). A survey conducted on users of the bike-sharing programme in Washington, D.C. found that 31.5% of respondents reported reduced stress and approximately 30% of individuals

Table 2
International bike-sharing schemes.

City	Country	Population	Year opened	Stations	Bicycles
Amiens	France	133,448	2008	26	250
Århus	Denmark	319,680	2007	57	400
Austin	USA	912,791	2013	46	375
Avignon	France	91,283	2009	17	200
Batumi	Georgia	125,800	2013	22	200
Belfast	UK	333,871	2015	30	300
Belfort	France	50,128	2013	21	200
Belo Horizonte	Brazil	1.4 m	2014	40	400
Berlin	Germany	3.5 m	2009	50	300
Besançon	France	116,914	2007	30	200
Blackpool	UK	142,065	2009	60	400
Bucharest	Romania	1.9 m	2008	6	400
Caen	France	108,954	2008	40	350
Calais	France	72,589	2010	37	160
Cergy-Pontoise	France	203,913	2009	42	320
Charlotte	USA	792,862	2012	21	200
Chattanooga	USA	173,366	2012	33	300
Clermont-Ferrand	France	141,569	2013	22	220
Columbus	USA	822,553	2013	30	300
Copenhagen	Denmark	591,481	2013	17	250
Cork	Ireland	119,230	2014	31	330
Dijon	France	151,212	2008	39	400
Frankfurt am Main	Germany	717,624	2009	30	300
Galway	Ireland	75,530	2014	15	195
Girona	Spain	97,227	2009	10	260
Győr	Hungary	128,380	2015	23	180
Indianapolis	USA	852,866	2014	25	300
Kansas City	USA	467,007	2012	30	300
Kraków	Poland	759,131	2008	34	230
La Rochelle	France	80,014	2010	63	300
Lausanne	Switzerland	133,897	2013	23	251
Ljubljana	Slovenia	277,554	2011	33	215
Limerick	Ireland	95,854	2014	23	215
Luzern	Switzerland	78,786	2008	30	280
Madison	USA	243,344	2011	39	350
Málaga	Spain	566,913	2013	20	400
Mulhouse	France	111,156	2007	40	240
Namur	Belgium	110,558	2012	24	200
Nancy	France	105,421	2009	29	250
Nyon	Switzerland	29,593	2011	13	167
Opole	Poland	122,120	2012	16	164
Orléans	France	114,167	2007	33	300
Palma	Spain	399,093	2011	28	336
Perpignan	France	117,419	2008	15	150
Stuttgart	Germany	604,297	2007	64	400
Tampa	USA	347,645	2014	30	300
Valence	France	62,481	2010	20	380
Yokohama	Japan	3.6 m	2011	15	300

stated they had lost weight due to the bike-share system (Alberts et al., 2012). Bike-sharing has also been associated with an increase in mobility and correlations have been discovered between the close coupling of bike-sharing and transit stops with higher usage rates (Nair et al., 2012).

Due to the potential achievable benefits through the incorporation of bike-sharing schemes in cities there is a growing volume of research into bike-sharing systems. One study focused on understanding the diffusion of public bike-sharing systems in Europe and North America using quantitative and qualitative analyses to explore the reasons for adoption decisions in different cities; it was found that both Europe and North America are experiencing a major adoption phase with new systems emerging and growth in existing systems, and that private sector operators have been important entrepreneurs in both locations with respect to technology and business models (Parkes et al., 2013). A further study concentrated on the impacts and processes of the implementation and operation of bike-sharing systems and specifically whether they are achieving their core objectives; this study found benefits in terms of improved health, increased transport choice and convenience, reduced travel times and costs, and improved travel experience, but concluded that these benefits are unequally distributed since typical users are young males in more advantaged socio-economic positions. Furthermore, the study states that there is no direct evidence that bike-sharing significantly reduces traffic congestion, carbon emissions, or pollution (Ricci, 2015).

In a global context, one study focused on mining data from 38 bikesharing systems using an extensive database of the geographical location and bicycle occupancy of each docking station, and analysis was conducted on the variation of

Table 3
List of studies.

Study	City	Scheme size (No. Bikes)	Analysis type
O'Neil and Caulfield (2012)	Dublin	550	Survey and data mining
Jiménez et al. (2016)	Dublin	1500	Data mining
Fishman et al. (2015)	Melbourne and Brisbane	600 (Melbourne) 2000 (Brisbane)	Survey
O'Brien et al. (2014)	Multiple cities	NA	Data mining
ÓTuama, 2015	Dublin	550	Interviews (survey)
De Chardon and Caruso (2015)	Multiple cities	NA	Data mining
Shaheen et al. (2014)	Multiple cities	NA	Expert survey and user survey
Shaheen et al. (2012)	Multiple cities	NA	Expert survey and user survey
Zhao et al. (2014)	Multiple cities	NA	Data mining
Daito and Chen (2013)	Washington D.C.	2800	Full data analysis
Tang et al. (2011)	Multiple cities	NA	Survey
Wang et al., (2013)	Minneapolis	1550	Data mining
Hampshire and Marla (2012)	Barcelona and Seville	6000 (Barcelona) 2100 (Seville)	Data mining
Zhao et al. (2015)	Nanjing	1100	Full data analysis
Beecham and Wood (2014)	London	11,500	Full data analysis
Gebhart and Noland (2014)	Washington D.C.	2800	Full data analysis
Faghih-Imani and Eluru (2015)	Chicago	3000	Full data analysis
Corcoran et al. (2014)	Brisbane	2000	Full data analysis
Kaplan et al. (2015)	Copenhagen	1860	Survey

occupancy rates over time in order to infer the likely demographics and intentions of user groups. The purpose of the study was to inform operators and policymakers on maintenance, suitable locations for future infrastructure installations, and better targeting of promotional materials to encourage new users (O'Brien et al., 2014). Data mining was also used in order to analyse operational data from bike-sharing systems to derive bike activity patterns at bike-sharing stations (Vogel et al., 2011). A further study was concentrated on utilising global bike-sharing data to analyse road safety, where it was discovered that the introduction of a bike-share system is associated with a reduction in cycling injury risk and bike-share users are less likely than other cyclists to sustain fatal or severe injuries (Fishman and Schepers, 2016).

Much of the research conducted to date on bike-sharing schemes tends to take one or more of three general approaches. The approaches typically are:

1. Surveying users or managers of the scheme
2. Data mining of data from online sources of usage at stations
3. Obtaining data from the bike-sharing operator

Table 3 lists several studies that have examined various aspects of bike-sharing schemes. This list is not meant to be exhaustive; its purpose is to demonstrate the various means of examining bike-sharing as listed above. Table 3 shows that the literature relies on a number different methods of analysis to provide insights into how bike-sharing schemes operate.

There are currently four cities in the Republic of Ireland with bike-sharing facilities, located in Dublin, Cork, Limerick, and Galway. There are currently over 100 bike stations in Dublin (with a minimum of 15 stands at each station) and over 1500 bicycles (Dublinbikes, 2016), whilst in Cork there are 31 stations and 330 bicycles (Coca-Cola Zero, 2016). Coca-Cola Zero has entered into partnership with the bike-sharing schemes in Ireland, with branding applied to each individual bike in return for investment in the schemes (Dublinbikes, 2014). The bike-sharing systems operate on a subscription basis with options available for an annual pass or a three-day pass. Tiered pricing is incorporated based on the duration of a journey made by each bike user, with the first thirty minutes of each journey being free. The dublinbike scheme is considered one of the most successful bike-sharing schemes in the world (Daly, 2011), with the volume of long-term subscribers surpassing 58,000 by December 2015 and over 3.7 million trips made in 2015 (Dublinbikes, 2015).

The role of bicycle sharing in an Irish context was studied through a survey analysis, where it was discovered that the bike-sharing scheme in Dublin City: is used predominantly by higher-income individuals; has a different functionality during the peak and off-peak travel times; and has been indirectly successful at improving driver awareness towards cyclists (Murphy and Usher, 2015). A further study focusing on dublinbikes sought to explain the "ripple effects" associated with the incorporation of a bike-sharing scheme in a city. The study examined a number of domains including rules and regulations, user experiences of navigating the city, the emergence of new factors, the development of infrastructures, and traffic management measures. It was found that the introduction of the Dublin bike-sharing scheme set in motion an array of unpredicted processes and cascade effects, including the generation of new experiences of the city, a greatly increased usage of bicycles in some key areas, economic growth, and shifts in dominant transportation activities (ÓTuama, 2015).

3. Overview of the usage of the bike-sharing scheme

This section of the paper provides an overview of the usage of the scheme during the evaluation period. In this section the data used is detailed, as are some of the usage trends related to the data.

3.1. Data

The National Transport Authority (NTA) of Ireland provided the data used in this study. The data is from 2015 and represents the first full year of operation of the Cork Bikes Scheme. The original dataset contained approximately 290,000 trip records. Prior to the evaluation some cleaning of the data was conducted. The first set of data to be removed related to those on temporary passes (three days) using the scheme. These were removed as they were considered to be visitors to the city and would not reflect the patterns of native users. This assumption was made as these passes cost €3 for three days whereas the annual memberships cost €10. This resulted in removing less than 2000 or less than 0.7% trip records. The second set of data removed were those trips of less than one minute. These were removed as they were assumed to be trips in which the bike wasn't removed from the station and was just put back once the bike was take out. This resulted in just over 20,000 or 7% of trip records being removed from the dataset. The data provided for this research was anonymised so therefore no information on the age or gender of the users was provided. The authors realise this is a limitation of the research, however the findings presented in the subsequent sections do provide several interesting findings on the operation of the bike-sharing scheme.

3.2. Examining trends in the usage data

The first set of results presented in this section detail the variables used in subsequent modelling sections and the explanations of these variables are also contained in Table 4. These variables also provide some insight into the usage patterns of the scheme. Travel time is the first variable examined. The results show that the majority of the trips conducted in the scheme are short trips with over 70% of trips less than 9 min. Fig. 2 shows the distribution of travel time, again showing the amount of short trips that take place in the scheme. As individual identifiers such as age and gender were not available for this study, it

Table 4
Description of variables used in the MNL model.

		N	%
Travel Time	Less than 4 mins	58,417	22.3
	4–6 mins	65,300	25.0
	6–9 mins	68,494	26.2
	Over 9 mins	69,167	26.5
Frequency of usage	Every day	47,129	18.0
	At least twice a week	110,547	42.3
	At least once a week	48,746	18.6
	Less than once a week	54,956	21.0
Usage of the bike station	Busiest Stations (over 50 trips per day)	80,755	30.9
	Busy Stations (49–30 trips per day)	73,624	28.2
	Less busy stations (29–20 trips per day)	52,679	20.2
	Least busy stations (less than 20 trips per day)	54,320	20.8
Trip OD	Same origin and destination	10,509	4.0
	Different origin and destination	250,869	96.0
Frequency of origin and destination pair	Over 1000 trips	42,410	16.2
	999–500 trips	67,823	25.9
	Less than 500 trips	151,145	57.8
Day of the week	Weekday	215,895	82.6
	Weekend	45,483	17.4
Time of day	AM Peak	46,557	17.8
	Off Peak – Afternoon	92,982	35.6
	PM Peak	84,144	32.2
	Off Peak – Night	37,695	14.4
Rainfall	Below 2.7 mm	186,298	71.3
	Above 2.8 mm	75,080	28.7
Minimum average temperature	Below 5.3 degs	64,802	24.8
	5.4–8 degs	62,702	24.0
	8–9.9 degs	66,891	25.6
	Above 9.9 degs	66,983	25.6
Hours of sunshine	Less than 0.7 h	68,178	26.1
	0.71–3.3 h	61,055	23.4
	3.4–7.4 h	66,491	25.4
	More than 7.4 h	65,654	25.1
Distance travelled	Less than 852 m	59,356	22.7
	852–1288 m	64,653	24.7
	1289–1848 m	67,366	25.8
	Greater than 1849 m	70,003	26.8

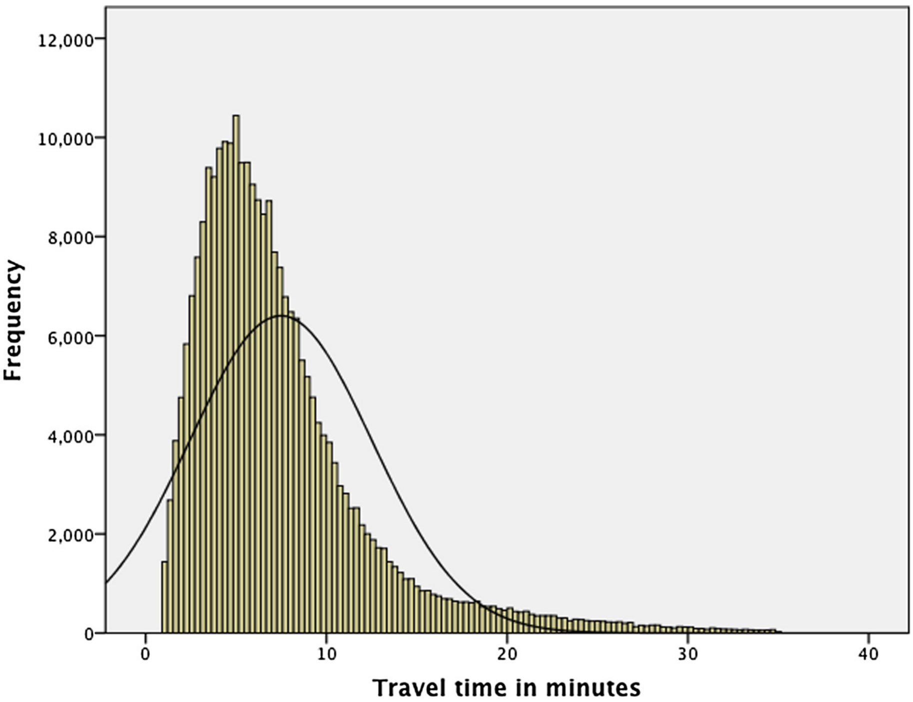

Fig. 2. Distribution of travel time.

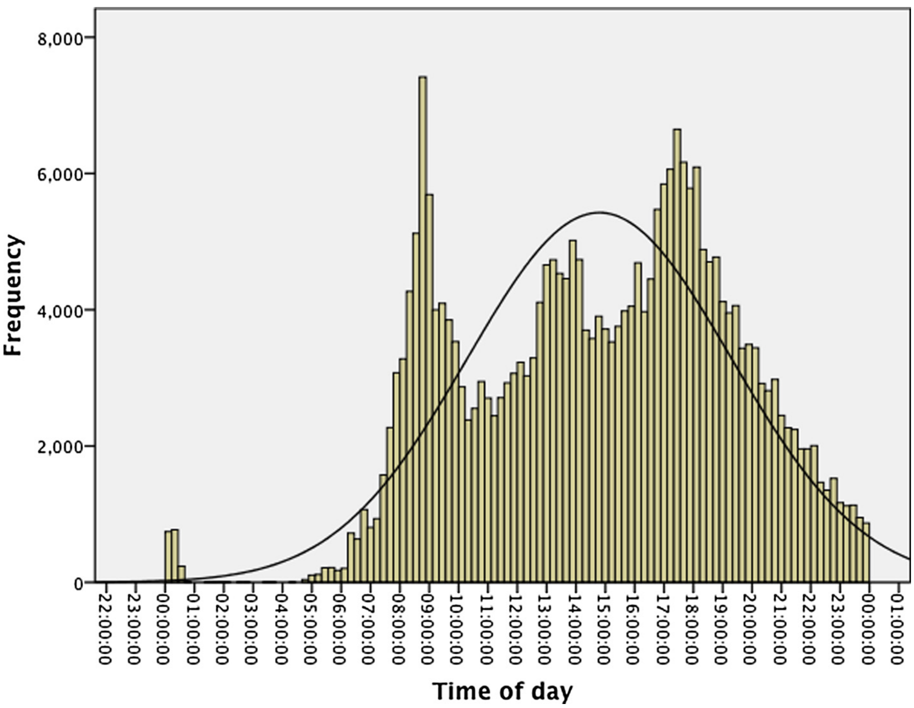

Fig. 3. Distribution of rental times.

was deemed important to find a variable that would show how often people used the scheme. A frequency of usage variable was created to demonstrate how often people used the scheme. The results show that about 18% of people use the scheme on a daily basis, and almost 60% of users use the scheme once or twice a week. One aspect of the scheme that was examined is how busy the stations are. The busiest stations are categorised as having over 50 trips per-day and the stations with the lowest

Table 5
Examination of travel time.

Trips by day of the week	Average travel time	Standard deviation	Standard Error
Monday	9 min	20.9	0.10
Tuesday	9 min	23.6	0.10
Wednesday	9 min	18.9	0.08
Thursday	10 min	24.5	0.11
Friday	9 min	22.8	0.10
Saturday	12 min	46.4	0.28
Sunday	13 min	30.8	0.21
User type			
Everyday	8 min	18.6	0.08
At least twice a week	9 min	20.8	0.06
At least once a week	10 min	26.7	0.11
Less than once a week	13 min	38.5	0.13
Time of Day			
AM Peak	8 min	17.5	0.07
Off Peak – Afternoon	11 min	30.0	0.09
PM Peak	10 min	22.4	0.07
Off Peak – Night	9 min	32.6	0.16
Frequency of OD pair			
Over 1000 trips	8 min	10.8	0.05
999–500 trips	10 min	24.7	0.09
Less than 500 trips	11 min	30.4	0.08

demand have less than 20 trips per day. The results in Table 3 show that approximately 60% of all trips originate from the busiest stations in the scheme. The other variables examined that relate to the usage of stations was did the trips from the bike stations have the same origin and destination, the results showed that only 4% of all trips fell into this category. Another variable examined was the frequency of origin and destination pairs (or routes) within the network. The origin and destination pairs were deemed to be the most popular if over 1000 trips on these routes were recorded and least popular if less than 500 trips occurred. The results showed that the majority of trips recorded on the least popular routes.

The final set of results examines weather and time of day variables. The results show that over 82% of trips were recorded on a weekday. The results for time of day show that majority of trips occur in the off peak period from 10am to 4 pm and in the evening peak between 4 pm and 6 pm. Fig. 3 details a breakdown of the number of trips taken across the day. A morning and evening peak is apparent as well as a steady usage during the afternoon off-peak period. The rain variable was estimated by taking the average rain fall in Cork over 2015 and estimating if the trips took place in a day above or below this average rain fall of 2.7 mm of rain. This weather data was taken from the weather station at Cork Airport (Met Éireann, 2016) The findings show, as one might expect, more trips took place on days where the rainfall was below average. The other weather variables (temperature and hours of sunshine) were segmented by quartiles so there is more or less an even split between these quartiles. Further interpretation of the impacts of these weather conditions on trips is conducted in Section 3.2. The final variable examined is the distance travelled by users of the scheme. This distance is the distance estimated as the distance between bike stations and it is not a distance that is measured by monitoring or tracking cyclists in the network. Therefore the distance may not be accurate but it does give a good indication of distance travelled. The results for distances show that the majority of trips are short trips. This finding corresponds to the travel times recorded.

This section of the paper examines some of the usage trends in the data. Table 5 details some of the travel time statistics. The results for the day of the week show an average trip time of 9–10 min, this increases to 12–13 min at the weekend. This maybe points to a difference between commuters and casual users. The standard deviation and standard error values for the weekend also increase demonstrating a greater degree of variation in travel times at the weekend. The second set of results examines how the frequency of usage impacts upon travel time. The result show that those that use the scheme most frequently have the lowest average travel times and a lower standard deviation and standard error of travel time, compared to those that use the scheme less frequently. The results for the time of day travelled shows that the shortest travel times were recorded in the AM Peak followed by the off-peak nighttime. The final set of results in Table 5 report the travel time for the most popular OD (origin – destination) pairs in the network. The findings show that the most popular OD pairs have the lowest average travel time and standard deviation and standard error of travel time.

4. Methods and results

4.1. Modelling approach

A logistic regression model was used to examine trends within the dataset. The modelling approach uses travel time as segmented into four categories in Table 4 as the dependent variable against several independent variables also outlined in Table 4. The model takes the following functional form:

Table 6
Logistic regression model results.

		Less than 4 min	4–6 min	6–9 min
	Intercept	−4.403**	−2.316**	−0.829**
Frequency of usage	Every day	1.304**	0.803**	0.378**
	At least twice a week	0.771**	0.491**	0.302**
	At least once a week	0.303**	0.181**	0.186**
	Less than once a week	0[b]	0[b]	0[b]
Usage of the bike station	Busiest Stations (over 50 trips per day)	0.448**	0.251**	−0.041*
	Busy Stations (49–30 trips per day)	0.276**	0.205**	0.073**
	Less busy stations (29–20 trips per day)	0.014**	0.103**	−0.016**
	Least busy stations (less than 20 trips per day)	0[b]	0[b]	0[b]
Trip OD	Same OD	0.093**	−1.420**	−1.678*
	Different OD	0[b]	0[b]	0[b]
Frequency of OD pair	Over 1000 trips	0.235**	−0.061*	0.119**
	999–500 trips	0.085**	0.033*	0.091*
	Less than 500 trips	0[b]	0[b]	0[b]
Day of the week	Weekday	0.290**	0.246**	0.179**
	Weekend	0[b]	0[b]	0[b]
Rainfall	Below 2.7 mm	−0.148**	−0.135**	−0.107**
	Above 2.8 mm	0[b]	0[b]	0[b]
Minimum average temperature (degrees)	Below 5.3 degs	−0.013**	−0.014**	−0.021**
	5.4–8 degs	0.094**	0.046**	0.026*
	8–9.9 degs	0.109**	0.093**	0.087**
	Above 9.9 degs	0[b]	0[b]	0[b]
Hours of sunshine (in hours)	Less than 0.7 h	0.102**	0.148**	0.099*
	0.71–3.3 h	0.104**	0.095**	0.067**
	3.4–7.4 h	0.229**	0.330**	0.234*
	More than 7.4 h	0[b]	0[b]	0[b]
Distance travelled (meters)	Less than 852 m	5.363**	2.341**	−0.030**
	852–1288 m	4.596**	3.239**	1.029**
	1289–1848 m	2.224**	2.074**	1.251**
	Greater than 1849 m	0[b]	0[b]	0[b]
Time of day	AM Peak	0.584**	0.379**	0.262**
	Off Peak – Afternoon	−0.608**	−0.379**	−0.190**
	PM Peak	−0.576**	−0.354**	−0.135**
	Off Peak – Night	0[b]	0[b]	0[b]
N				261,378
−2Log-likelihood at convergence				14344.080
Nagelkerke R^2				0.452
Chi-squared statistic				11359.358
Degrees of freedom				69

* Significant at a 95% level.
** Significant at a 99% level.
[b] This parameter is set to zero because it is redundant.

$$\log it(\mathrm{p}) = \log\frac{p}{1-p} = a + \beta T + \delta BS + e$$

where p is the probability that the event occurs, in this case it is that the trip travel time falls into one of the quartiles examined, βT is the set of trip characteristics (distance travelled, weather conditions, time of the day, day of the week and frequency of shared bike usage), δBS is the set of bike station characteristics (usage of the bike station, trip OD and frequency of origin and destination pair) and e is a random error term.

4.2. Results of the logistic regression model

The results of the logistic regression model are presented in Table 6. The model examines the factors that impact upon trip duration. The Nagelkerke R^2 of 0.452 indicates a good model fit. The model provides several interesting insights into the usage of the bike-sharing scheme in a small city. The first set of results shows the most frequent users of the scheme are likely to have the shortest journeys. This perhaps suggests that those who use the scheme most frequently do so for habitual short journeys. Trips from the busiest stations in the scheme were also found to be the shortest trips, this supports the thesis that trips in this scheme are habitual and short. The second set of results that relate to the bike station show the shortest trips (less than 4 min) were likely to be round trips from the same bike station, with longer duration trips likely to have a different origin and destination (as one would expect). The results for frequency of OD pair (or popularity of a route) shows that the most popular routes have the shortest travel times, this again supports the idea of frequent habitual routes.

The findings also show that shorter trips are likely to take place on weekdays. As one might expect, the results of the rainfall variable show that when rainfall is above average, shorter journeys are more likely. The results for both temperatures and hours of sunshine show that shorter trips are more likely on warmer and brighter days. The final two variables estimated examine how distance and time of day impact upon the travel time. The distance travelled variable, as one would expect, shows that those travelling shorter distances were likely to have the shortest travel times. The final set of variables examined in Table 4 measure the impact of time of day travelled on trip duration. The findings show that in the morning peak period the shortest trip times were recorded.

The results presented in Table 6 provide a number of interesting findings on travel time on the Cork Bikes scheme. When considering the variables linked to the usage of the stations, the popularity of OD pairs and the frequency of individual usage, the results seem to suggest the system has a set of regular users that have habitual trips that they take on a daily or at least weekly basis in the network. Further research is needed to determine if these trips are new trips or are these trips as a result of modal shift.

5. Conclusions

As discussed in this paper, bike-sharing, is one of the fastest growing modes of shared mobility globally and is changing attitudes to cycling and sharing transport infrastructure. This paper provides details of one of the most recently launched bike-sharing schemes in Ireland. The results show that even though Cork a city without a strong cycling culture, that the scheme is being used frequently.

One of the key things this paper considered was usage patterns within the bike-sharing scheme. The findings show the majority of trips in the scheme were short and in most cases frequent trips. Frequent users of the scheme were shown to have the shortest travel times, suggesting these users have incorporated the scheme into their daily (or weekly) trips. Weather conditions were also found to have an impact upon usage of the scheme. During good weather conditions the number of trips and travel time was shown to be greater.

Comparing the results of this analysis with other schemes in larger cities, a number of parallels emerge. The presence of AM and PM peaks is seen in cities such as Chicago (Zhou, 2015), however is very different to systems such as Montreal's BIXI (Faghih-Imani et al., 2014), where the system appears to be most popular in the evening and at weekends. The habitual use of the scheme for commuting mirrors trends seen in cities such as Toronto (El-Assi et al., 2015), while the presence of shorter trips in the morning may be equivalent to the high speeds observed for AM peak trips by Jensen et al. (2010) in Lyon. The presence of longer trips at the weekend for the Cork scheme is also seen in an examination of the Chicago system (Zhou, 2015), while Noland et al. (2016) in their analysis of shared bikes in New York also recognise the differences exist between weekday and weekend usage, and casual and regular users. This would suggest that while the Cork scheme is on a much smaller scale than some of the others presented in the literature, there does appear to be a number of similarities with larger schemes and their associated behaviours.

The findings of this paper do provide valuable insights as to how a bike-sharing scheme works in a small city. More research is needed on these smaller schemes to understand how the dynamics of the schemes differ from those schemes in larger cities like New York and London. The findings also inform discussion on schemes in even smaller cities, given that the results found in Cork show very small trip times, could this mean that in even smaller cities trip times would be smaller. However, while the trip times are shorter it is evidenced in the paper that the scheme serves the city and provides a strong function with these habitual short trips.

Acknowledgements

The authors would like to thank the National Transport Authority for access to the Cork Bike dataset.

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