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Barriers to bikesharing: an analysis from Melbourne and Brisbane

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ABSTRACT

This study quantifies the motivators and barriers to bikeshare program usage in Australia. An online survey was administered to a sample of annual members of Australia's two bikeshare programs based in Brisbane and Melbourne, to assess motivations for joining the schemes. Non-members of the programs were also sampled in order to identify current barriers to joining bikeshare. Spatial analysis from Brisbane revealed residential and work locations of non-members were more geographically dispersed than for bikeshare members. An analysis of bikeshare usage in Melbourne showed a strong relationship between docking stations in areas with relatively less accessible public transit opportunities.

The most influential barriers to bikeshare use related to motorized travel being too convenient and docking stations not being sufficiently close to home, work and other frequented destinations. The findings suggest that bikeshare programs may attract increased membership by ensuring travel times are competitive with motorized travel, for example through efficient bicycle routing and priority progression and, by expanding docking station locations, and by increasing the level of convenience associated with scheme use. Convenience considerations may include strategic location of docking stations, ease of signing up and integration with public transport.

1. Introduction

In 2010, Brisbane and Melbourne introduced bikeshare programs (BSPs) in their city centers and some of the local surrounding inner suburbs, known as *CityCycle* and *Melbourne Bike Share* (*MBS*) respectively. Bicycle riding participation has not increased significantly in either Brisbane or Melbourne between 2011 and 2013, with around 15–17% of the population riding at least once in a typical week (Austroads, 2013), although these aggregated figures may hide localized differences. Australia's bikeshare usage has not been as strong as anticipated (Brisbane Times, 2011; Fishman, 2012; Fishman et al., 2013; Fyfe, 2010), with usage rates significantly less than other BSPs (Fishman et al., 2013; Meddin, 2011). Both schemes started with approximately 0.2–0.5 trips per day per bike. Usage has increased since launch but by the end of 2012, neither program had reached one trip per day per bike (Hoernel, 2013; Lundberg, 2013). Most other schemes internationally report usage rates of around 3–6 trips per bike per day (Fishman et al., 2013). There has been widespread speculation as to reasons behind the lower usage rates in Australian cities, yet relatively little empirical research has been conducted.

This paper sets out to examine two key questions. Firstly, what are the major factors acting as barriers to bikeshare membership in Australia? Secondly, what are the major motivators for bikeshare members to have joined Australia's two BSPs? These questions have been developed to help shed light on why Australia's bikeshare usage has been significantly lower than BSP in other countries.

Table 1 provides an illustration of some of the key metrics of the Brisbane and Melbourne BSPs. To offer context, three other BSPs have also been included.

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Table 1
Bikeshare program size and usage – selected cities. *Sources: MBS* bike and trips (Hoernel, 2013), *CityCycle* bikes and trips (Lundberg, 2013), Brisbane and Melbourne population (Australian Bureau of Statistics, 2013), London data (Greater London Authority, 2012; Stanhope, 2013; Woodcock et al., 2014), Washington, DC data (Capital Bikeshare, 2013; Wikipedia, 2012). All data 2012 unless otherwise stated.

	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

[a] New York City data (NYC Bike Share, 2013; Wikipedia, 2014) from July 2013 to December 2013.
[b] Fleet total for 2012 (2013 for NYC), which may not reflect actual number of bicycles in circulation.
[c] Based on data from 2012. Trips less than 2 min or greater than 3 h have been excluded, as they are likely to have been the result of operator or technical error, and are unlikely to represent a genuine trip.

2. Literature review

This section provides a brief overview of some of the literature examining bikeshare. The first BSP began in Amsterdam in the 1960s, but theft and vandalism led to a rapid demise (DeMaio, 2009). Major technological developments now allow bikeshare operators to integrate payment, security and tracking technologies into their systems, mitigating many of the problems associated with early BSPs (DeMaio, 2009). The different stages of bikeshare development have led some researchers to define the stages as 1st, 2nd, 3rd and 4th generation (DeMaio, 2009; Shaheen et al., 2010). First and 2nd generation programs suffered from theft and vandalism due to user anonymity. These experience, as noted by DeMaio (2009) gave rise to what can be described as a 3rd generation BSPs, characterized by docking stations, automated credit card payment and other technologies, such as radio frequency ID tags and GPS. It is these elements that have contributed to the burgeoning bikeshare market worldwide (Shaheen and Guzman, 2011) and both Australian BSPs can be classed as 3rd generation, although Brisbane's BSP does not currently offer credit card swipe access. The growth in bikeshare has coincided with major technological developments and affordability of electric bikes. It is plausible that the next generation of bikeshare may include electric bikes and indeed there are some programs already offering 'e-bike share' (Ji et al., 2013).

The availability and affordability of these new technologies have combined with what Pucher and Buehler (2012) have identified as a growing enthusiasm for urban bicycling, leading to a rapid growth in this new form of public transport. Although constantly changing, there are now no less than 700 cities operating BSPs across the globe (Fishman et al., 2014), from small pilot programs through to those in Wuhan and Hangzhou, China with 90,000 and 70,000 bikes respectively (Larsen, 2013). The purported benefits of bikeshare have been identified by Shaheen et al. (2010) as flexible mobility, reduced emissions, increases in physical activity, congestion mitigation and fuel conservation, individual financial savings and support for multimodal transport connections.

Underpinning many of the benefits often associated with bikeshare is an assumption that many of the trips are replacing car use Fishman et al., 2013; Midgley, 2011. In instances in which researchers have been able to ask bikeshare users what mode they are replacing, it is very often other sustainable modes of transport, that is, walking, public transit, or a private bike trip. For instance, Murphy (2010) found some 66% of the users of the Dublin BSP were substituting for a walking trip. In London and Washington, DC only 2% and 7% of users are substituting for car use (Fishman et al., 2014). Bachand-Marleau et al. (2011) found that only 2% of surveyed *BIXI* (the BSP in Montreal, Canada) replace trips previously made by car. In cities in which overall car use is higher, the proportion of bikeshare users replacing a car trip is higher. For instance, in Melbourne, Brisbane and Minneapolis/St. Paul around one fifth of bikeshare journeys replace a car trip (Fishman et al., 2014).

A number of researchers have examined the factors influencing bikeshare use. Bachand-Marleau et al. (2012) found convenience and the desire to avoid the theft of a private bike to be the key facilitators for *BIXI* use, something found by an earlier study of the same BSP (Fuller et al., 2011). Indeed *convenience* has emerged as one of the most important, overarching motivations for those using bikeshare. In one of the largest studies of its type, Shaheen et al. (2012) conducted an online survey with bikeshare members and operators of various programs in North America, with convenience emerging as the main motivating factor and this too was the finding of a separate study of the Washington, DC. BSP known as *Capital Bikeshare* (LDA Consulting, 2012). The convenience theme is not restricted to North America. Research undertaken by Transport for London (2011) on the *Barclays Cycle Hire* program showed its ability to enhance mobility is a key motivation for use. As shown in Section 2.1, Australian bikeshare users have also identified factors related to convenience as a major motivator for using bikeshare. The spatial configuration of docking stations is seen as a critical factor influencing bikeshare usage (Fuller et al., 2011). Geographic Information Systems (GIS) are beginning to be used as a method for determining docking station location, based on such factors as employment and residential densities (Garcia-Palomares et al., 2012).

2.1. Existing research on Australian bikeshare programs

Limited research exists within the peer-reviewed literature regarding the motivating factors that lead to bikeshare membership, and of the research that does exist, very few have focused on the Australian programs. Understanding what factors motivate people to join BSPs may be useful in future efforts to increase bikeshare usage, as it will yield an estimated relationship between the likelihood of joining the program as a function of key program features. The majority of research investigating bikeshare in Australia appears in the non peer-reviewed literature, most often in consultant and operator reports, some of which have been provided to the authors under an *Information Sharing Agreement* signed with the each of the Australian bikeshare operators and associated government partner.

The operators of the *MBS* program conducted a market research exercise approximately six months after the program launched. The research was motivated in part by lower than expected usage and to assist in determining the impact of recent initiatives such as helmet vending machines (mandatory helmet legislation exists in Australia) (Alta Bike Share, 2011). The survey was completed

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online by self-selected Internet users, as well as in the field by people walking in close proximity to *MBS* docking stations. Just under 500 people were surveyed in each method, resulting in a sample where 31% of respondents had used the *MBS* program. It is important to recognize that these survey methods limit the generalizability of the results due to self-selection effects, as the sample only includes people who have visited the *MBS* website or walked past specific docking stations and were willing to be part of the study. Nevertheless, the survey revealed some interesting findings with regard to the barriers and motivators to using *MBS*. Some 61% of respondents cited helmet issues as their main barrier (Alta Bike Share, 2011). Melbourne experienced a particularly wet period around the time of the survey (Bureau of Meteorology, 2011), and this may have contributed to the large proportion (16%) who cited 'bad weather' as a barrier. Convenience relative to other travel options was found to be the key motivator for those who used *MBS* (Alta Bike Share, 2011).

A more recent examination of the *MBS* program was undertaken on behalf of VicRoads (the statutory agency overseeing the program) (Traffix Group, 2012). This consultant report included two data collection methods; an online survey ($n = 602$) and intercept survey ($n = 2945$). The online survey, in which just under half the respondents reported having used the scheme, revealed that the main motivators for using *MBS* related to convenience, with the highest recorded reasons being; '*prefer the experience of cycling*', '*faster than public transport*', '*more convenient than public transport*' and '*close to origin/destination*'. The high proportion of respondents who had used *MBS* in this study may limit the generalizability of the results (self-selection bias). Multiple responses were permitted and participants were unable to select the degree to which these factors were motivators for using the scheme (such as a Likert scale).

The Traffix Group study also contained an open text field for respondents to provide a comment on the *MBS* program. When these comments were coded for commonly occurring categories, the researchers found that approximately 46% of respondents cited mandatory helmet legislation as having a negative impact on *MBS*. When participants were asked what prevented them from using *MBS* (or what prevented more frequent use by those who were members of the scheme), helmets continued to be a feature, with 24% saying they '*don't want to carry a helmet around*' (the highest response received), followed by '*live/work outside MBS area*' and '*docking stations not near origin/destination*'.

The views on helmets reported above are supported by US research conducted by Fischer et al. (2012) in which large differences were found in the helmet wearing prevalence between public and private bike riders in both Boston and Washington, DC. When controlling for sex, time of week, and city, the results showed a 4.4-fold greater chance of a bikeshare rider without a helmet than a private bike rider.

The research to date on bikeshare in Australia has established that convenience is a critical motivating factor, consistent with international research. This paper sets out to quantify the factors that act as barriers and facilitators to bikeshare use in Melbourne and Brisbane, in order to fulfill the gap that currently exists quantifying the factors that inhibit and promote bikeshare usage in Australia. The paper also documents motivators for current bikeshare use.

3. Methodology

To determine the major factors acting as barriers and motivators to bikeshare membership in Australia, an online survey instrument was developed and distributed to *MBS* and *CityCycle* annual members. These two groups were selected as they are the only BSPs in operation and serve as potentially useful sources of information regarding the motivating factors for membership. Invitations to participate were emailed to all bikeshare members by the operators of the respective BSPs. Invitations were also sent to members of a research panel managed by the Centre for Accident Research and Road Safety – Queensland, known as the *Independent Survey Panel in Road Safety* (InSPiRS) Panel. This Panel was selected as they had no known connection with bikeshare and may therefore offer a useful sample group for understanding potential barriers to bikeshare. The InSPiRS Panel is made up of a random sample of Queensland households and anyone is able to subscribe to be part of the Panel. According to the Panel's administrator, 125 of the emails were rejected or 'bounced' by the mail server. This Panel is used to gain responses from the general public and is a non-probabilistic sample. Sample numbers and response rates are provided in Table 2. Although the *CityCycle* sample was open to anyone who had signed up to the mailing list, results show that 97% of respondents were annual members. Some 133 of the emails sent by the *CityCycle* operator 'bounced' as well as seven from the *MBS* operator.

Each participant was aged over 18 years and lived, worked, or studied in the Brisbane or Melbourne areas. In recognition of their time, participants were offered the opportunity to enter a prize draw for one of ten $100 department store gift cards. The survey was developed in Key Survey (www.keysurvey.com). In accordance with the requirements of the Queensland University of Technology Research Ethics standards, each participant was provided with a participant information form and consent was implied if the prospective participant chose to proceed.

The surveys were launched in mid November 2012 and were open for two weeks. Sample groups were sent a reminder email after one week, with the exception of the *CityCycle* group, as the bikeshare operator has a policy of not sending more than one email per month to members. The survey was comprised of 39 questions, however significant branching and logic was employed to customize the questions based on responses to previous questions and for this reason, no respondent was presented with all 39 questions. For each of the three sample groups the surveys were identical apart from the use of Brisbane, Melbourne, *CityCycle* and *MBS*, which was altered to ensure relevance based on the respondents location. Each possible branching alternative was tested, with the time required to complete the survey being no more than 12 min. General themes included socio-economics and demographics, bikeshare membership status, transport behavior and vehicle ownership status. Specific questions focused on gauging the degree to which various factors inhibited BSP membership for those who had not become BSP members. The crucial question to this component on the survey was: '*If you were considering joining CityCycle, to what extent would these factors discourage you?*' (see Fig. 5 for the options provided). Respondents were provided with a 0–4 Likert scale in which 0 was '*Not at all*' and 4 was '*A lot*'. For simplicity of presentation, the mean scores only are reported. Similarly, bikeshare members were asked how important various factors were in them becoming members, with the question presented as: '*What motivated you to become a CityCycle/MBS member?*' See Fig. 7 for the options presented and results.

Five focus groups were held in Brisbane, in October 2011, with 30 people in total. *CityCycle* members, regular riders who were not *CityCycle* members as well as those who had not ridden a bike in the past month and were not *CityCycle* members were involved. Each participant lived, worked or studied in the Brisbane area. These focus groups provided the necessary understanding of opinions and attitudes related to bikeshare to develop the survey questions used in this study, as documented in Fishman et al. (2012a).

Spatial analysis of *MBS* usage is proposed, using data automatically collected whenever a bike is taken or returned, to illustrate

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Table 2
Survey sample and response rate.

	Melbourne Bike Share members	CityCycle members	InSPiRS Panel[a]
Sample sent invitation email	921	2490[b]	436
Successfully received emails	914	2357	311
Fully completed surveys received	372	443	60
Response rate	40.7%	18.8%	19.3%[c]

[a] Panel members needed to be 18 years or old, live, work or study in the Brisbane area and have an active email address.
[b] Of these, 1926 were to annual members.
[c] Cooperation rate.

patterns of usage that may be helpful in understanding user motivation. Additionally, spatial analysis of home and work postcodes of survey respondents is proposed. This is done to capture the spatial relationship between home and work and the bikeshare catchment area, including any differences that might exist between members and non-members. It is suggested this may elicit some barriers and facilitators that are spatial in nature.

Finally, factor analysis is proposed to quantify the barriers and facilitators to bikeshare, as this technique is an effective method of condensing a large number of variables into groups, or factors that have an underlying theme. Factors with an Eigenvalue greater than one will be included. In cases where only one item loads on a factor and weakly (below 0.3) on others on the Rotated Component Matrix this item can be removed and the FA redone. It is considered that a one item factor is not a factor per se and adds nothing to the factor structure. In these cases the items will be included in the ANOVA as a single item. Cross loading variables (loading on multiple factors, at a value greater than 0.3) will be removed. The removal of these items is done on the basis that the items cross-loading may indicate that they do not fit within the underlying structure and need to be considered separately. It also may be an indication that these variables do not measure what was intended and therefore have been poorly constructed. A repeated measures ANOVA is then proposed, as shown in Section 4.3.

4. Results and discussion

4.1. Descriptive analysis of Brisbane and Melbourne bikeshare usage

An examination of the survey results revealed similarities between bikeshare member groups and differences between these members and the InSPiRS Panel (non-members). Bikeshare members are typically younger, more likely to know the distance between their home and work to their closest docking station, have pre tax incomes above $A104,000 per annum, and have friends or family who are bikeshare members. Moreover, bikeshare members were considerably more likely to have ridden a bicycle (public or private) in the month prior to undertaking the survey. Table 3 presents some of the similarities and differences between sample groups, as well as comparison with the city population, drawn from Census data. Bikeshare members are in fact slightly older than the overall city population, perhaps as a consequence of the eligibility age at which someone is able to be a bikeshare member (17 and 15 years old in Brisbane and Melbourne respectively). Gender is evenly split within the Census, however both bikeshare member samples over-represent males, with this effect more pronounced in Melbourne (three out of four members are male). This finding is broadly consistent with well-established gender differences reported in cycling participation in Australia (Garrard, 2003; Garrard et al., 2006, 2007; Pucher et al., 2010).

Fig. 1 illustrates the distribution of age categories across each of the three sample groups.

The most heavily contrasting feature however is income, with the most frequent annual income for bikeshare members at the upper end of the spectrum, whilst Census data showing the general population occupying the other end of the spectrum (see Table 3). Fig. 2 provides an illustration of the distribution of income categories across the three sample groups. Previous research has shown bikeshare members in London have higher incomes than the city population (Transport for London, 2010b).

Members were asked about the frequency and purpose of bikeshare usage, with striking similarity between the two BSPs.[4] For commuting journeys, almost half the members in both Brisbane and Melbourne reported no usage in the month prior to undertaking the survey, whereas around 13% for both *MBS* and *CityCycle* reported using the BSP "everyday" (see Fig. 3).

4.1.1. Geospatial analysis of bikeshare usage – Melbourne

Melbourne bike share operators provided detailed ridership data to the research team (Hoernel, 2013). Each trip on *MBS* is automatically logged, with the use of Radio Frequency ID tags on each bicycle. At the time of writing November 2012 was the latest available data and this was used as the basis for Fig. 4, which includes 13,713 individual trips and 13% returning to the same docking station the bike was taken. Fig. 4 highlights the relationship between stations (i.e. dominant travel between one station and another). Any two stations recording more than 50 trips between them have been represented with a blue[5] line. The width of the line corresponds with the number of trips occurring between the two stations (see Legend). Public transit accessibility has also been included, using the established Public Transport Accessibility Levels (PTAL) methodology (Transport for London, 2010a). The PTAL is divided into 6 levels (1–6), with 6 representing high accessibility (shown as dark areas in Fig. 4).[6]

Many of the strongest trip patterns shown in Fig. 4 occur between stations located in areas of relatively weak public transit accessibility. This may be explained by the journey time competitiveness of bikeshare in these areas. Travel time is a key determinant of mode choice (Sener et al., 2009), it is likely the increased utility afforded by bikeshare in areas of lower public transit accessibility may help explain the relationships illustrated in Fig. 4. This is consistent with research conducted in Helsinki that found the greatest travel time savings associated with bikeshare and public transit can be found in areas in which the public transit network is less developed (Jäppinen et al., 2013).

[4] Actual question: Which of the following best describes your riding frequency and purpose on CityCycle/MBS bikes in the past month?
[5] For interpretation of color in Fig. 4, the reader is referred to the web version of this article.
[6] Public Transport Accessibility Levels (PTALs) are a measure of the accessibility of a point to the public transport network, taking into account walk access time, service availability and frequency. The method essentially measures; Walking time from the point-of-interest (POI) to the public transport access points (or service access point (SAP); reliability of the service modes available; the number of services available within the catchment; and the level of service at the public transport access points – i.e. average waiting time.

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Table 3
Descriptive statistics of sample groups.

Variable	Melbourne Bike Share $N = 372$	CityCycle $N = 443$	InSPiRS Panel $N = 60$	Greater Melbourne[b]	Greater Brisbane[b]
Most frequent age range	30–34 (16.9%)	30–34 (16.6%)	55–59 (19.8%)	25–29 (7.9%)	25–29 (7.9%)
Male	76.6%	59.8%	41.7%	49.2%	49.3%
Female	23.4%	40.2%	58.3%	50.8%	50.7%
Mean distance between home & work	10.7 km (SD 9.5)	8.6 km (SD 7.7)	13.2 km (SD 10.4)	10.0 km[d]	15.3 km[d]
Percentage living within 500 m of a docking station	44%	54.1%	5%[a]	NA	NA
Percentage working within 500 m of a docking station	83.9%	83.6%	15%[a]	NA	NA
Most frequent annual income range	$104,000 + (47.9%)	$104,000 + (26.3%)	$52,000–$64,999 (17.3%)	$10,400 or less (15%)	$10,400 or less (15%)
Car ownership	76.6%	80.4%	100%	NA	NA
Free car park at work	19.9%	26%	63.3%	NA	NA
Mean number of family/friends who are bike share members	0.59 (SD 0.87)	0.95 (SD 1.10)	0.05 (SD 0.28)	NA	NA
Most frequently reported bicycle riding activity in past month	16+ trips (35.8%)	16+ trips (33%)	No bicycle riding activity (75%)	NA	NA

[a] Approx. 50% of InSPiRS members responded "Don't know" in relation to the distance between their home and work and closest docking station.
[b] Australian Bureau of Statistics (2013).
[c] ABS 2006 Census, for South East Queensland (Doonan, 2010).
[d] ABS 2011 Census, reported *median* distance (Department of Transport Planning and Local Infrastructure, 2013).

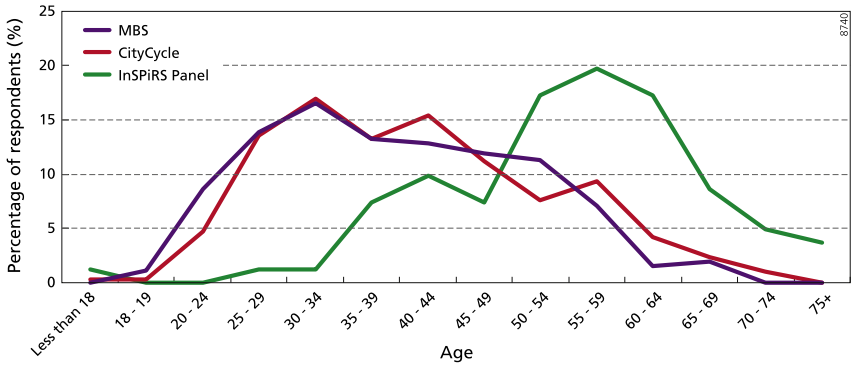

Fig. 1. Age range across sample groups. Sample numbers: *MBS* $N = 372$, *CityCycle* $N = 443$, InSPiRS Panel $N = 60$.

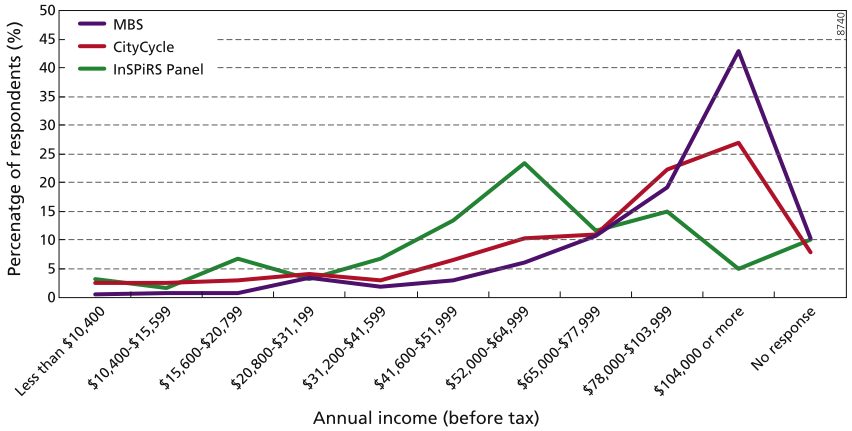

Fig. 2. Income range across sample groups. NB: Australian dollars. Sample numbers: *MBS* $N = 372$, *CityCycle* $N = 443$, InSPiRS Panel $N = 60$.

4.2. Analysis of barriers and motivators

4.2.1. Non bikeshare members – barriers and facilitators

In terms of barriers to bikeshare, convenience emerges as a key theme, with *Driving is more convenient, docking stations are not close enough to my house & work* and *I don't want to carry a helmet with me* each receiving the strongest responses. These results are consistent with research cited earlier showing convenience factors to be among the most important motivators for bikeshare use (Bachand-Marleau et al., 2012; Shaheen et al., 2012). Safety concerns whilst riding in traffic also received among the highest mean scores and is consistent with the findings of previous research (Webster and Cunningham, 2012).

The same sample group was also asked what would encourage them to consider becoming a bikeshare member. There were no dominant variables when comparing means, as shown in Fig. 6. Those factors related to safety and convenience do however show slightly stronger responses, with *more bike lanes and paths* and *automatically open to GoCard*[7] *holders* receiving the strongest mean scores. Interestingly, the third strongest factor was *nothing; I am*

[7] GoCard is the SmartCard public transit ticketing used in Brisbane.

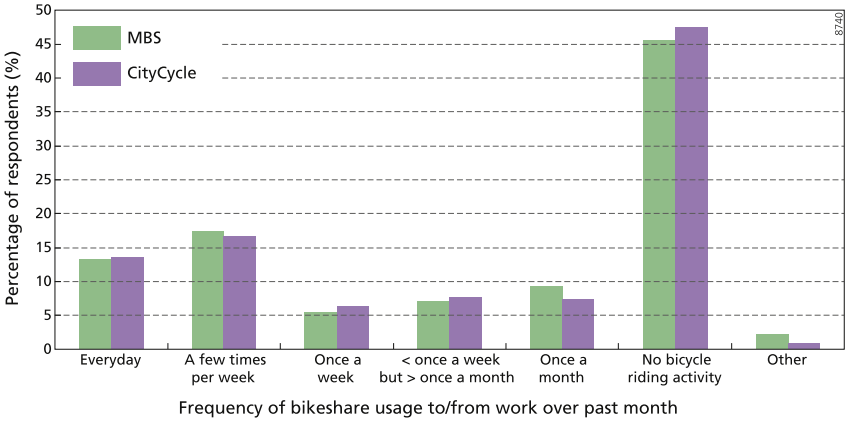

Fig. 3. Frequency of bikeshare commuting over past month.

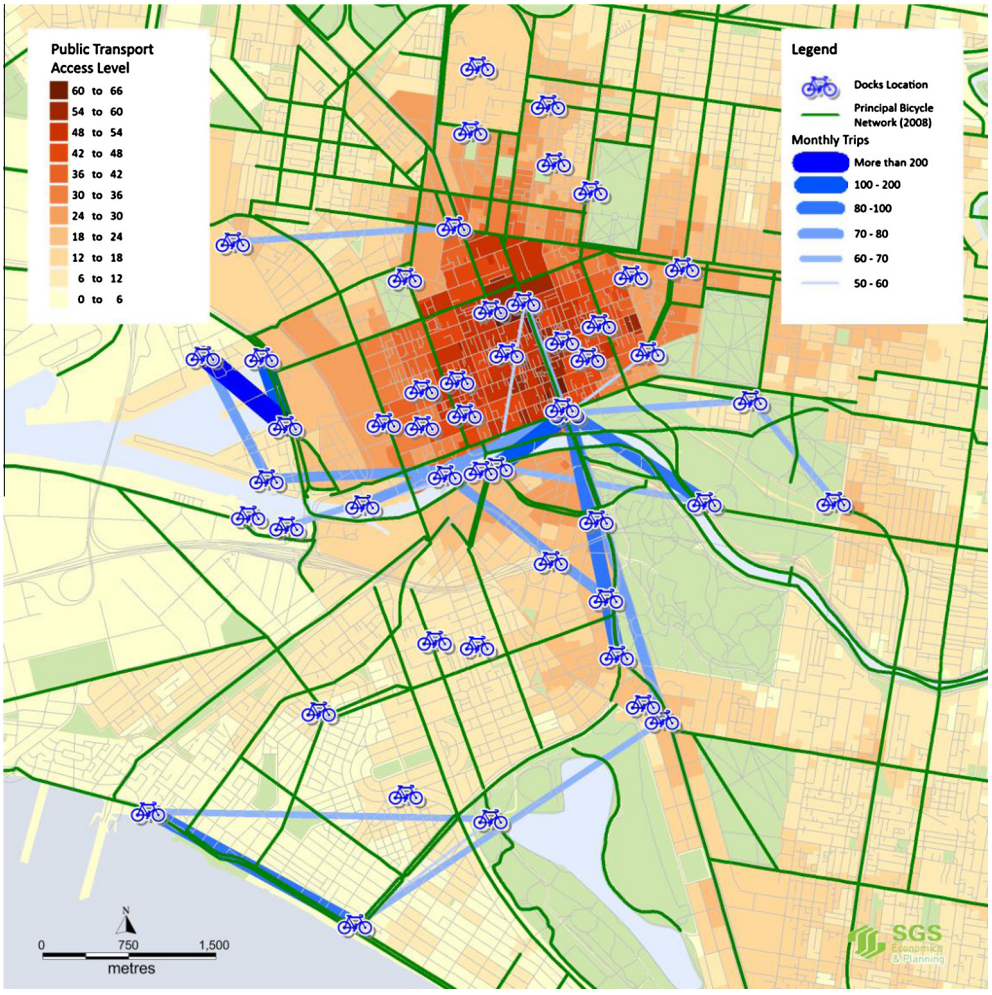

Fig. 4. Major relationships between docking stations – *MBS*, November 2012.

not interested in using CityCycle, no matter what. Relaxing mandatory helmet laws, which is frequently cited as a key reason for the lower usage of Australian BSPs, received the lowest rating of all possible factors offered in the survey question. To some extent this may simply reflect the fact they these respondents were overwhelmingly non-bike riders. For those that do not ride a bike, there may be other factors more important than mandatory helmet legislation that prevents them from riding. Recent research found a lack of immediate access to helmets to be a critical barrier to bikesharing in countries in which they are mandatory (Fishman et al., 2012a).

4.2.2. Bikeshare members – motivating factors

Current bikeshare members, in both Brisbane and Melbourne were asked their motivation for joining, with the results presented in Fig. 7. Very little difference is apparent between Brisbane and Melbourne sample groups, in terms of the motivation for joining.[8]

[8] Being a bikeshare member does not imply regular use. In fact, some 10% of members responding to the survey, in both Melbourne and Brisbane stated they had not ridden any type of bike in the month prior to undertaking the survey. This suggests barriers to bikeshare exist even for those who are members.

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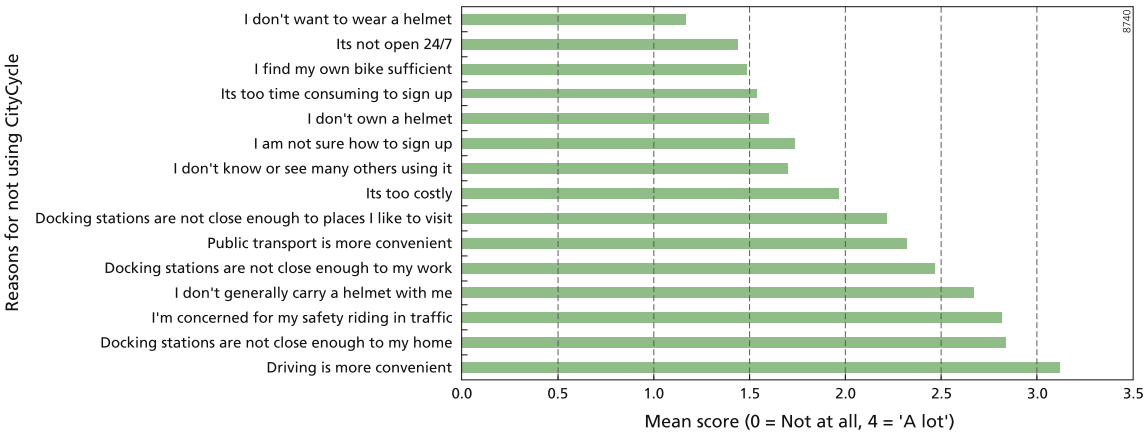

Fig. 5. If you were considering joining *CityCycle*, to what extent would these factors discourage you?

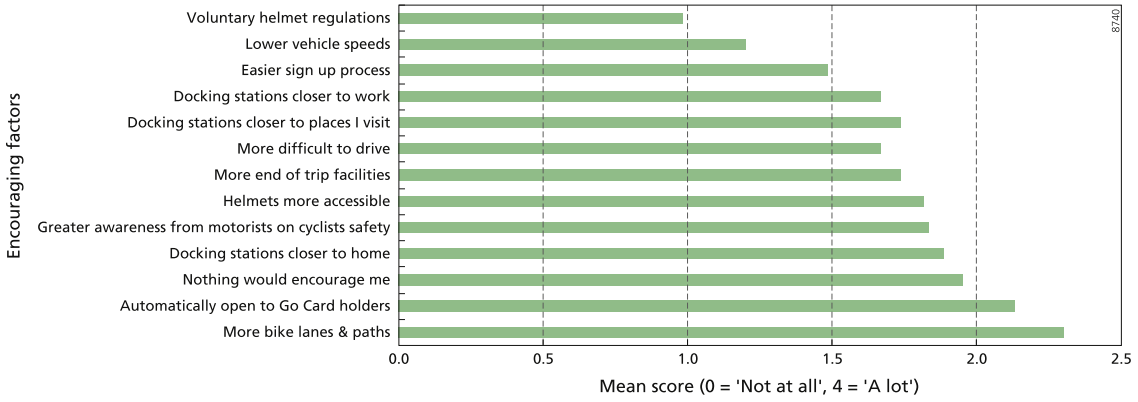

Fig. 6. To what extent would these factors encourage you to become a *CityCycle* member?

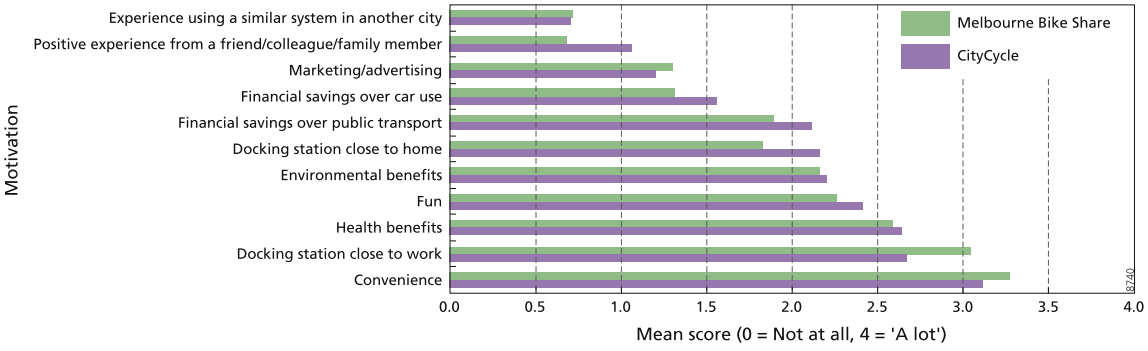

Fig. 7. What motivated you to become a *CityCycle/MBS* member?

The strongest responses were received for *convenience* and *docking station close to work*. This latter finding may not reflect inherently greater importance of work/docking proximity (as compared to home/docking station proximity). This finding may be influenced by the configuration of the bikeshare docking station catchments and this is especially so for Melbourne. The *MBS* program is particularly small relative to the size of the city (600 bikes and a Greater Melbourne population of approximately four million). The docking stations are largely in central employment districts, rather than residential neighborhoods. Therefore, the finding that distance between docking station and work was more powerful than the distance between home and docking station may be influenced by the current catchment configuration.

Melbourne Bike Share members revealed several factors as being unimportant in their decision to become bikeshare members. Some 74% and 70% of respondents said that *Using a similar system in another city*, and *a friend or family member* had no influence over their decision to become a bikeshare member. Marketing campaigns were considered of little influence, with 58% of respondents saying it had either no, or very little influence. As with *MBS* members, factors considered to have no influence over the decision to join *CityCycle* included *Using a similar system in another city* (73%), and *a friend or family member* (58%). Again, marketing was also a weak influence, with 63% of respondents identifying it as having either no, or very little influence.

4.2.3. Geographical distribution of home, work and docking stations

Figs. 8–10 provide a geospatial indication of home and work locations for all sample groups, as well as the position of the bikeshare docking stations. These maps have been created in ArcMap V10.2 (http://www.esri.com) using the geocode for home and work postcodes provided by respondents to the online survey, with some refinements made using Adobe Illustrator CS6 (http://adobe.com). Melbourne Bike Share members (Fig. 8) home postcodes

Fig. 8. Greater Melbourne: distribution of *MBS* members' home and work postcodes, and docking stations.

(represented by squares) are most heavily concentrated within the inner city and eastern suburbs, with lower frequencies reported in outer suburbs. Work locations (represented by shaded circles), are highly concentrated in the CBD, overlapping the docking station (transparent circles) catchment area. This is consistent with data in Fig. 7 showing the importance of docking stations close to work locations as a key motivating factor for people to sign up as members.

CityCycle members display a similar distribution to *MBS* members, with a heavy concentration of residential locations within the inner city, particularly within the inner southwest and CBD (Fig. 9). Places of employment, as with *MBS* members, are heavily skewed towards the CBD. Readers comparing Figs. 9 and 10 should refer to the Legend used in each figure, as the symbol sizes refer to different magnitudes, as a consequence of the different sample sizes.

The InSPiRS Panel has a distribution different to that of both bikeshare member groups. Residential and work locations are more heavily dispersed, with less focus on the inner city area. The map in Fig. 10 has been 'zoomed out' relative to Fig. 9, in order to capture the wide dispersal of residential and work addresses.

4.3. Factor analysis and repeated measures ANOVA

4.3.1. Non-members – barriers to bikeshare (CityCycle)

Factor analysis was performed to group variables presented in Fig. 5 into a smaller group of *latent* variables, as described in Washington et al. (2011). This process resulted in five factors, made up of the following variables,[9] as shown below:

F1 Docking station inconvenience:	Docking stations are not close enough to work.
	Docking stations are not close enough to home.
	Docking stations are not close enough to places I like to visit.
F2 Scheme difficulty of use:	It's too time consuming to sign up.
	It's too costly.
	I am not sure how to sign up.
	Public transport is more convenient.
F3 Helmet inconvenience:	I don't generally carry a helmet with me.
	I don't own a helmet.
	I don't want to wear a helmet.
F4 Car convenience	Driving is more convenient.[a]
F5 Perceived danger	I'm concerned for my safety riding in traffic.[a]

[a] These variables were added as additional factors within the repeated measures ANOVA, as they received among the highest mean scores in descriptive statistics.

[9] '*Its not open 24/7*', '*Driving is more convenient*' and '*I'm concerned for my safety riding in traffic*' were removed due to cross loading.

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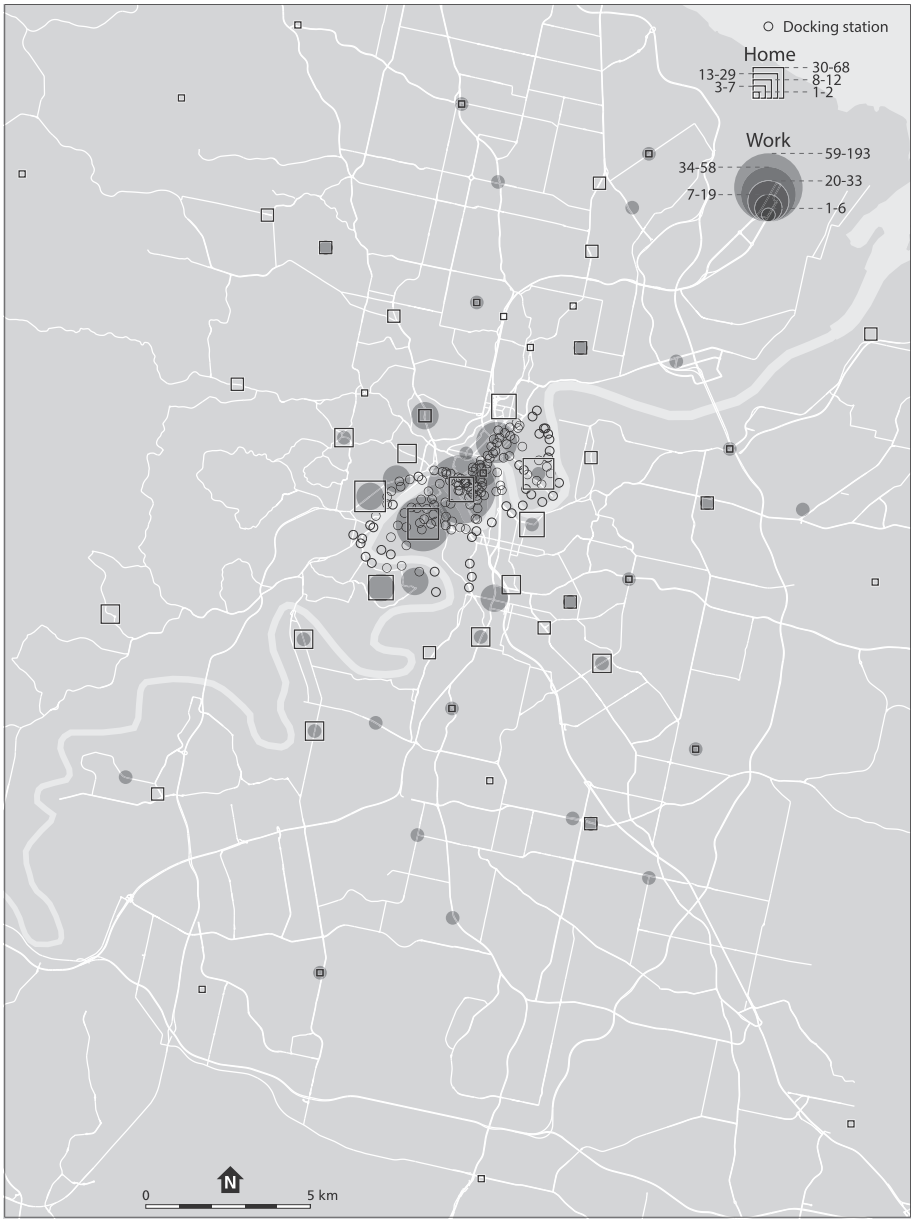

Fig. 9. Greater Brisbane: distribution of *CityCycle* members' home and work postcodes, and docking stations.

Table 4 provides the mean scores for each of the factors and Table 5 offers a comparison of the mean scores for each factor.

As shown in Table 5 *docking station inconvenience* was a greater influence against bikeshare membership than *scheme difficulty of use* and *helmet inconvenience*, but less of a key influence compared to *car convenience* and *perceived danger*. These two factors, *car convenience* and *perceived danger* were found to be the most influential barriers to bikeshare membership, when compared to each of the other factors presented in Table 5.

The results presented in this section suggest convenience is a key influence on transport choice. Specifically, this is revealed in the strong mean score for *car convenience*, as well as for *docking station inconvenience*. These two self-reported factors are claimed by respondents to deter their membership in *CityCycle*. These results are drawn from survey respondents based in Brisbane and they may not be immediately transferable to other cities, although they have revealed themes that have been previously established in the literature. As cited earlier, travel time is a key determinant of travel mode choice (Sener et al., 2009) and the convenience of driving and proximity of docking stations both relate directly to travel time. Whilst there may be factors unique to Brisbane, conceptually, these findings have relevance to other cities with, or looking to establish bikeshare programs. Moreover, *perceived danger* received the second highest mean score, and this finding is consistent with qualitative research which has shown fear of motorized traffic to be a key impediment to bikesharing (Fishman et al., 2012a).

4.3.2. Non-members – facilitators to bikeshare

The repeated measures ANOVA was performed using the variables in Fig. 6. Once cross loading variables were removed,[10] the rotated component matrix could not be produced, as only one factor (but eight variables) remained.

Despite the unsuccessful repeated measures ANOVA, insight into bikeshare facilitators can be drawn from Section 4.3.1 – *Barriers to bikeshare*, as they are essentially the inverse. Introducing policies

[10] Cross-loading variables included: 1st analysis: "*Nothing would encourage me*", 2nd analysis: "*Helmets more accessible* and "*Easier sign up process*", 3rd analysis: "*Automatically open to Go Card holders*" and "*More difficult to drive*".

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Fig. 10. Greater Brisbane: distribution of InSPiRS Panel members' home and work postcodes, and docking stations.

Table 4
Estimated marginal means – Barriers to bikeshare for non-members.

	Mean	Standard deviation	Std. error	95% confidence interval	*N*
Docking station inconvenience	2.5	1.48	0.19	2.1–2.9	60
Scheme difficulty of use	1.9	1.11	0.14	1.6–2.2	60
Helmet inconvenience	1.8	1.23	0.16	1.5–2.1	60
Car convenience	3.1	1.21	0.15	2.8–3.4	60
Perceived danger	2.8	1.49	0.19	2.4–3.2	60

Wilks' Lambda $F = 12.372$ with a significance of <0.001.

designed to reduce the convenience of driving and the targeted expansion of docking stations within residential, employment and activity centers is likely to provide the conditions in which non-members may begin to view bikeshare as a realistic option.

4.3.3. Members – motivators to join

Survey respondents who were bikeshare members (*CityCycle* and *MBS*) were asked '*What motivated you to become a bikeshare member?*' (see Fig. 7). Factor analysis was performed to group variables presented in Fig. 7 into a smaller group of *latent* variables. This process resulted in three factors, made up of the following variables,[11] as shown below:

[11] Cross-loading variable removed was "*Experience using another bikeshare system*".

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Table 5
Pairwise comparisons.

Bikeshare barriers factors	Barriers	Mean difference	Std. error	Sig.[a]	95% confidence interval for difference[a]	
					Lower bound	Upper bound
Docking station inconvenience	Scheme difficulty of use	.618[b]	.192	.021	.058	1.178
	Helmet inconvenience	.694[b]	.215	.020	.068	1.321
	Car convenience	−.611[b]	.189	.020	−1.163	−.059
	Perceived danger	−.311	.218	1.000	−.948	.325
Scheme difficulty of use	Docking station inconvenience	−.618[b]	.192	.021	−1.178	−.058
	Helmet inconvenience	.076	.159	1.000	−.388	.541
	Car convenience	−1.229[b]	.181	.000	−1.757	−.702
	Perceived danger	−.929[b]	.214	.001	−1.554	−.304
Helmet inconvenience	Docking station inconvenience	−.694[b]	.215	.020	−1.321	−.068
	Scheme difficulty of use	−.076	.159	1.000	−.541	.388
	Car convenience	−1.306[b]	.206	.000	−1.907	−.704
	Perceived danger	−1.006[b]	.217	.000	−1.639	−.372
Car convenience	Docking station inconvenience	.611[b]	.189	.020	.059	1.163
	Scheme difficulty of use	1.229[b]	.181	.000	.702	1.757
	Helmet inconvenience	1.306[b]	.206	.000	.704	1.907
	Perceived danger	.300	.165	.744	−.182	.782
Perceived danger	Docking station inconvenience	.311	.218	1.000	−.325	.948
	Scheme difficulty of use	.929[b]	.214	.001	.304	1.554
	Helmet inconvenience	1.006[b]	.217	.000	.372	1.639
	Car convenience	−.300	.165	.744	−.782	.182

[a] Adjusted for multiple comparisons using Bonferroni.
[b] The mean difference is significant at the 0.05 level.

Table 6
Estimated marginal means – motivators to join bikeshare, for members.

	Mean	Standard deviation	Stand. error	95% confidence interval	*N*
Perceived lifestyle benefits	2.1	0.85	0.03	2.04–2.16	797
Savings and social	1.6	1.02	0.03	1.51–1.66	797
Convenience	3.0	1.03	0.03	2.94–3.09	797

Wilks' Lambda $F = 465.951$ with a significance of <0.001.

Table 7
Pairwise comparisons.

Motivators for bike share	Motivators	Mean difference	Std. error	Sig.[a]	95% confidence interval for difference[a]	
					Lower bound	Upper bound
Perceived lifestyle benefits	Savings and social	.509[b]	.039	.000	.415	.603
	Convenience	−.916[b]	.045	.000	−1.025	−.808
Savings and social	Perceived lifestyle benefits	−.509[b]	.039	.000	−.603	−.415
	Convenience	−1.425[b]	.047	.000	−1.537	−1.313
Convenience	Perceived lifestyle benefits	.916[b]	.045	.000	.808	1.025
	Savings and social	1.425[b]	.047	.000	1.313	1.537

[a] Adjusted for multiple comparisons using Bonferroni.
[b] The mean difference is significant at the 0.05 level.

F1: Perceived lifestyle benefits:	Fun
	Environment
	Health
	Marketing
F2 Savings and social	Financial savings over car use
	Financial savings over public transport
	Positive experience from friend/colleague
	Docking station close to home
F3 Convenience	Docking station close to work
	Convenience

Table 6 provides the mean scores for each of the factors and Table 7 offers a comparison of the mean scores for each factor.

Convenience represents the strongest motivator for bikeshare membership and is consistent with previously reported research (LDA Consulting, 2012; Shaheen et al., 2012). *Perceived lifestyle benefits* represent a stronger collection of motivators for bikeshare membership than *savings and social*. In essence, the presence of a docking station close to work and the convenience offered by bikeshare were the most powerful motivators leading to bikeshare membership. It should be noted that Melbourne, and to a lesser extent Brisbane, both have bikeshare catchments concentrated within major employment centers, without significant residential populations. This may contribute to '*docking station close to work*' and '*docking station close to home*' being separated into different factors.

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5. Limitations

Every reasonable action has been taken to ensure the validity of the results, however several limitations have been identified. The authors cannot be certain all responses were received from those within the three sample groups. It was made clear in the instructions not to pass the survey hyperlink on to others, and this may reduce but not eliminate, the possibility that this occurred. In addition, the InSPiRS Panel is not fully representative of the general population. Moreover, only 60 fully completed responses were received, insufficient for generalizing the results at the population level. There may also be some differences between this sample group (who have volunteered to be part of a university research panel) and the general population (non-response bias). The dispersed residential locations of the InSPiRS Panel meant that a greater proportion of this group lived outside the *CityCycle* catchment, and this makes them a less than ideal control group. Nevertheless, the sampling techniques employed for this study were selected in an effort to avoid a 'snowballing' sample, which would have had greater distortive impacts in relation to how that sample group may have differed from the wider population. In the future, sampling techniques designed to capture non-members who live or work within the geographical area typical of members may provide an improved method of understanding barriers and facilitators to bikeshare.

As the survey invitation was sent out by the operator, and only to their list (*MBS* = 100% annual members, *CityCycle* 97% annual members) casual users were, in the main, not included in the study and it is possible their preferences and travel behavior may differ from that of annual members. Finally, the survey relies on self reported behavior and it is possible some survey respondents provided information that did not reflect their behavior or circumstance, although there would be little motive for knowingly doing so. Self reported estimates of distance between home and work and proximity to docking stations may be subject to inaccuracies.

Key strengths of the study include the sampling of non-members. It is not typical of bikeshare research to include those without a known connect to a BSP and this is a useful method of understanding barriers to bikeshare. Moreover, the representation of respondents home and work postcode, relative to docking station catchment using GIS tools presents an advance on previous research.

6. Conclusions

This paper has analyzed the survey results of non-members and members of Australia's two BSPs. This analysis contributes to existing knowledge by quantifying the current barriers and motivators to bikeshare, including those spatial in nature, in the context of Australia's two BSPs. Spatial analysis of home and work locations illustrate more dispersed work locations of non-members, with members work locations typically concentrated in central city areas, within the bikeshare catchments. The longer commute distance experienced by non-members (who were also overwhelmingly non-riders) is generally consistent with the findings from a Cambridge investigation showing a strong association between longer commute distances and car use (Carse et al., 2013). Furthermore, the finding that the convenience of car driving is a significant barrier to bikesharing is supported by the Cambridge study, which found free workplace car parking to be strongly associated with car use (Carse et al., 2013).

Considerable variation in docking station activity was evident, with some stations recording almost 10 times more activity than others. The stations that showed the strongest connection (most trips between one-another) were typically located in areas of relatively poor public transport accessibility. This finding is consistent with previous research (Jäppinen et al., 2013) and emphasizes the importance of travel time competitiveness as a motivation for bikesharing, something reported by a majority of respondents to a survey on Capital Bikeshare in Washington, DC (LDA Consulting, 2012). Spatial analysis of bikeshare infrastructure and usage patterns offers a helpful technique for practitioners and researchers seeking to understand and enhance the performance of BSPs, a conclusion shared by Garcia-Palomares et al. (2012).

Key barriers to bikeshare membership included *car convenience* and *docking station inconvenience*. *Perceived danger* emerged as a major barrier to bikeshare membership and is consistent with previous research indicating fear of collision is a major barrier to bicycling generally, in Australia (Cycling Promotion Fund, 2011; Fishman et al., 2012b; Garrard et al., 2006), the UK (Horton et al., 2007) and the US (Gardner, 2002). Interestingly, *helmet inconvenience* did not feature at the top of the list of barriers, despite the issue of mandatory helmet legislation featuring prominently in the ongoing debate regarding lower than expected take up of bikesharing in Australia. Not wanting to *carry* a helmet rather than not wanting to *wear* a helmet received a stronger mean score, and this is consistent with previously cited US research showing bikeshare users are considerably less likely to wear helmets compared to those riding private bikes (Fischer et al., 2012). When non-*CityCycle* members were asked what would encourage them to become members, more bike lanes and paths received the strongest mean score, followed by automatic membership for *Go Card* holders. Interestingly, *nothing would encourage me* received the third highest mean response. This finding suggests *CityCycle* may simply be beyond consideration for some in Brisbane. Only 1% of trips to work in Brisbane are by bicycle (Australian Bureau of Statistics, 2013), and this, among other factors may have the effect as shown by Basford et al. (2002) of seeing cyclists as an *out-group*. The barriers previously reported may culminate in a manner in which *CityCycle* is difficult to even consider as an option. These findings underpin the importance of sampling *potential* BSP members, rather than restricting sampling to those who have already become members.

Key motivators for current bikeshare members to become members included *convenience* (of bikeshare). This is consistent with North American research surveying bikeshare users, who consistently place convenience as the major motivator for bikesharing (LDA Consulting, 2012; Shaheen et al., 2012). A subcomponent of convenience is the presence of a docking stations close to work. Canadian research has found those living within 250 m of a docking station are more than twice as likely to have reported using bikeshare (Fuller et al., 2011). Research conducted with students in Valencia, Spain found the odds of using bikeshare increased by a factor of 15 for those with at least one docking station within 250 m of home (Molina-Garcia et al., 2013).

By addressing the barriers to bikeshare, and strengthening the attributes that have previously acted as motivators for people to join bikeshare, Australian BSPs may be able to grow membership and usage levels. Specific policy recommendations include: increasing the BSP catchment size, especially in Melbourne, increasing helmet accessibility, and expanding the provision of separated bicycle infrastructure. Reducing the convenience of car use also presents a potentially effective method of increasing bikeshare usage in Australia. This final recommendation may prove controversial but based on the data presented in this paper, could be a potent method of bringing Australian BSPs usage levels closer to international norms. Additional research with large samples of non-BSP members is required to better understand the barriers to bikeshare.

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