BIKE USAGE IN PUBLIC BIKE-SHARING: AN ANALYSIS OF THE "BIKEMI" SYSTEM IN MILAN

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BIKE USAGE IN PUBLIC BIKE-SHARING: AN ANALYSIS OF THE "BIKEMI" SYSTEM IN MILAN

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ABSTRACT

The constant increase of public shared bicycle systems (PSBSs) in western cities suggests that nowadays city councils consider public bike sharing systems a serious alternative to traditional public transportation in urban areas. PSBSs can represent a solution in the hands of citizens for short journeys in highly urbanized areas. In this paper we focus on the successful example of Milan's *BikeMi* PSBS which is giving very positive results in terms of satisfaction for all the actors involved, i.e. the service management, city council and users. From the available data it can be inferred that the bicycle overcome the car central areas in terms of speed, distance travelled daily, and choice of multiple itineraries, especially during peak periods and in proximity of the main railway stations. The main bicycle tracks and hotspots are also detected revealing an imbalance between the northern and the southern part of the city, with the northern part better covered by the service.

Keywords: Mode of transport, Bike-sharing, Poisson regression, Urban Mobility

JEL Codes: R41, R42, R49.

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1. INTRODUCTION

In the last years, the growth of urban population combined with the increase of traffic congestion, environmental pollution and fuel prices have driven urban developers and city councillors to experiment new sustainable mobility systems, including Public Shared Bycicle Systems (PSBSs). This phenomenon is having important positive consequences in terms of employment, public and private investments and citizen approval. Cycling is attracting renewed attention as a mode of transportation that is both environmentally friendly and beneficial for human health (Pucher et al., 2010), but also as a valid alternative to the car in highly congested cities. With the spread of the economic crisis in the last five-six years in the U.S. and in Europe, socioeconomic factors are increasingly emerging as major determinants of bike usage together with other “traditional” factors like meteorological conditions, season and weekday usage (Smith and Kauermann, 2011).

Previous literature on cycling has focused on social and health benefits, but data limitations have often produced unsatisfactory results. Nowadays, the development of PSBSs for the general public is forcing managers and decision makers to develop increasingly sophisticated management systems based on GPS automated software, satellite control and automated bike docking stations, paving the way for the production of a huge amount of data. This new scenario offers the opportunity to perform up-to-date evaluations of the effects of PSBSs on urban transport systems that are useful for key changes in transport and environmental policies and for the quality of life in urban areas.

Common features of PSBSs are: (i) a shared pick-up mode with easy-to-access docking stations conveniently distributed in the urban area; (ii) an unrestricted usage in terms of origin and destination; (iii) penalties imposed for misuse. However, there are also differences. For example, business models adopted to manage the service differ from context to context, ranging from completely public to completely private systems, with public-private mixed forms largely more popular. Involved operators include local governments, public transport agencies, advertising companies, for-profit and non-profit groups (Midgley, 2011; Shaheen et al., 2011). Some PSBSs are integrated with bus and underground public transport systems, some are not. The success of a PSBS depends on many variables, but, above all, it changes over time, so that a continuous monitoring is needed (Lathia et al., 2012).

The *BikeMi* PSBS in Milan is not exception, being the biggest and most innovative system in Italy and presenting many specificities and differences with other PSBS. In this paper we outline its main features and make comparisons with other PSBSs in Europe in terms of speed and traffic volumes. Section 2 summarizes the recent literature on bike-sharing systems. Section 3 is devoted to a brief outline of the main characteristics of *BikeMi*. Section 4 presents a short portrait of an average user, whereas Section 5 shows a short description of the evaluation of the system in terms of speed and preferred bike paths. Section 6 presents some results of a model for average bicycle check-in and check-out counts. Section 7 concludes the paper and presents some possible developments.

2. RECENT LINES OF RESEARCH IN BIKE-SHARING

The development of public bike sharing systems has grown steadily over the past 15 years especially in Europe, North America and Australia as well as in China and other Asian countries. Modern systems of mobility, shared with bicycles available in fully automated stations, were launched as pilot projects at the end of the 90's, prompting renewed interest from 2002 onwards. These systems have certain shared characteristics: (i) bicycles are equipped with locking pins and chips that identify them through unique codes; (ii) docking stations are connected via radio antennas and/or WI-FI infrastructure for data processing; (iii) electronic payment methods are used through virtual stores on the internet created for customers. As for the first quarter of 2014 there are over 800 fully automated active systems in the world, offering the opportunity to use public bicycles in major cities. The literature related to bike sharing has also steadily grown, while creating distinct lines of research that will be summarized below.

One first important line of research is focused on the design of bicycles and stations. Such studies often evolve into proposals for patents on the feasibility of hypothetical systems, often relative to small villages or college campuses (Geng, 2009). A second line of research (in which this study lies) is related to the statistical modelling of geospatial data (O'Brien et al., 2013; Smith and Kauermann, 2011). These studies often aim at suggesting policies, strategies and best practices to policy makers and managers of bike sharing systems.

A third line of research covers the major technological development that has led to the "renaissance" of bike sharing systems in 2000, after the first experimental attempts during the 90's. With the introduction of fully automated stations, combined with the development of electronic systems for payment and electronic applications for smart phones, the number of users has almost doubled in the last years. In engineering, computer and electronic research fields a huge number of studies have been proposed focusing in particular on the impact of specific hardware as well as software, in most cases supported by research departments of US universities, in central and northern Europe for the impact of new software applications and communications within the social networks, whilst China and India have been leading the hardware research (Cellina et al.,2013).

A fourth line of research is purported to develop sociological approaches that describe bike-sharing customers' behaviour. Research methods in this case are often qualitative, and are based on online surveys, telephone interviews, and seldom on focus groups with service users (Shaheen et al., 2011). The most important studies have been developed in the United States and Canada, sometimes in collaboration with researchers from China, Taiwan and Korea.

Recently, the European Union is increasingly pushing to introduce policies for mobility having low impact on the environment, and is currently financing sharing-economy projects like the OBIS (Optimising Bike Sharing in European Cities - www.obisproject.com) with the contribution of many academics from around the world. Likely, it is this latest EU policy that has put Europe ahead of Asia and America in promoting and funding, sometimes also directly, infrastructures and plans for the creation of this type of public transport in large and medium cities.

The countries with the most developed public bike-sharing systems are Spain, Portugal, China, Germany, France and Italy. Although Italy is the country with the highest number of active bike sharing systems this has not stimulated the interest of local researchers as, for example, in London and Paris where the development of the London Barclays Hire and Velib, bike-sharing systems has established new research centres and produced a huge amount of scientific publications.

Organizations promoting bike usage and associations of ecologists sometimes jointly fund research projects based on the environmental impact of bicycles on urban paths and the implementation of bike lanes. At the same time, in many health research in the US, benefits from the bike exercise in terms of fitness and reduction of cardio-circulatory illnesses for adults have been definitely proved: for example, making regularly the journey to work by bike has a positive effect on the daily life of people. US researchers are hoping for a more widespread acceptance of the bike usage in North America especially to reduce obesity and related illness.

Bike-sharing research embraces a multitude of other scientific fields, from statistical modelling for predicting users' movements to planning studies for the development of new public transport solutions, to the use of the GIS software. In this latter case an increasing number of operators of public bike sharing systems is asking for new technologies to monitor the traffic with real time applications to be easily handled in smart-phones and web-portals (e.g.: "the world bike share map" or the Ollie O'Brien's "bike share project"[3]).

In conclusion, the entire ecosystem of research studies developed until now creates a foundation for developing automated logistics software to manage and balance these public transportation systems in the next future. In the years to come, PSBSs will see further innovations, including the introduction of electrically assisted bicycles. Finally, the huge availability of data made available to the widespread public will create some web-based interactions and allow cyclists to dynamically review and monitor their progress during trips to and from their workplace.

[3] http://oobrien.com (accessed on Jan 6th, 2015).

3. THE *BIKEMI* PSBS

The *BikeMi* PSBS started in November 2008 and was the first privately managed bike shared system introduced in Italy. At present, 3,600 bikes are distributed across 207 stations over a 13 Km^2 urban area centred in the Duomo main square (Figure 1).

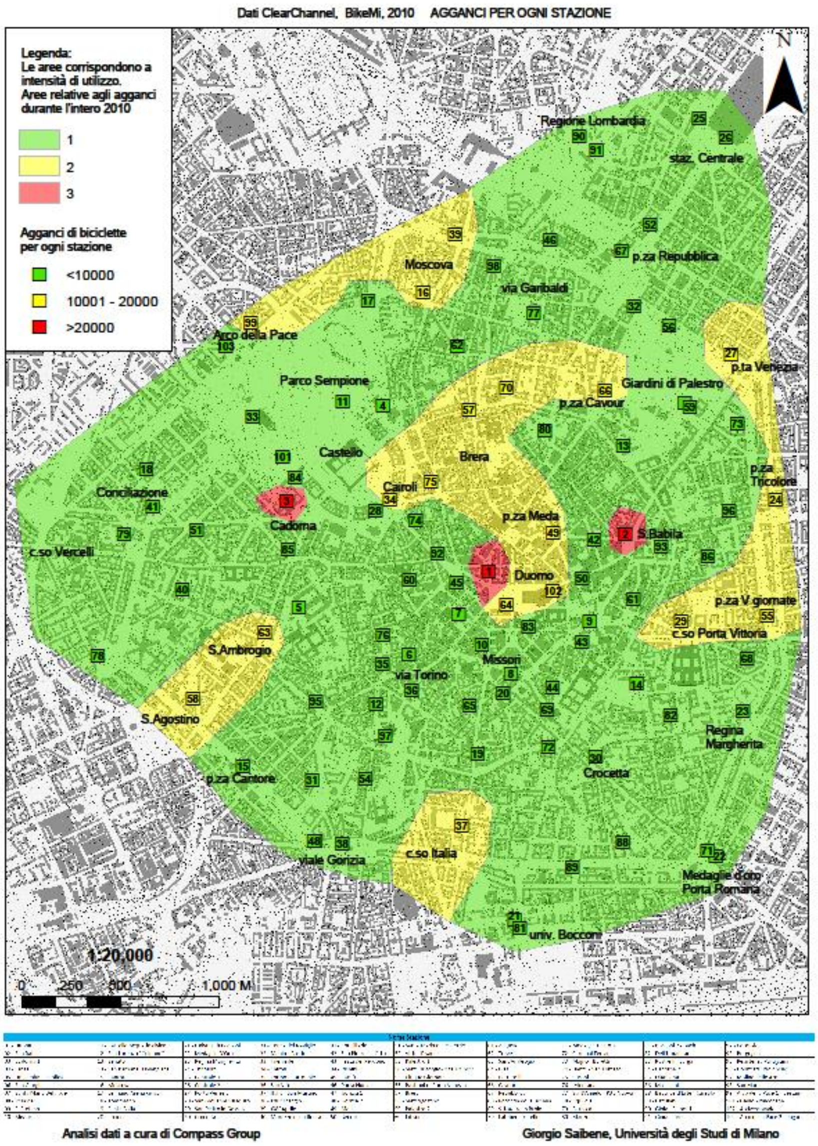


Figure 1 – Spatial distribution of docking stations and bike usage (2010)

A credit card is required in order to sign up to the service. A call centre and an official website are available to customers. Membership is prized by duration: 2.5 Euros for a daily subscription, 6 Euros for the week subscription and 36 Euros for a whole year. The *BikeMi* card is issued for free, but its re-issuing cost is 5 Euros. The first 30-minute usage is free (a common policy for SSBS systems), with a subsequent fare increase based on blocks of 30-minute increments. Subscription is suspended after 3 missed returns with a maximum fine of 150 Euros.

The *BikeMi* database is provided and maintained by the managing company Clear Channel. The dataset used in this work contains information on all trips that occurred daily between

December 1, 2008 and December 31, 2012. Some data are available also for part of 2013. Each record in the dataset provides details on departure and arrival times, the geographic area covered and the identity of the user.

From 2009 to 2012, both the number of stations (red vertical bars in Figure 2) and the average number of daily journeys (blue vertical bars in Figure 2) have considerably increased, the first from around 90 to around 160, the second from almost 2,000 to almost 4,000. During traffic congestion events like public transportation strikes or political rallies, the number of daily journeys usually doubles.

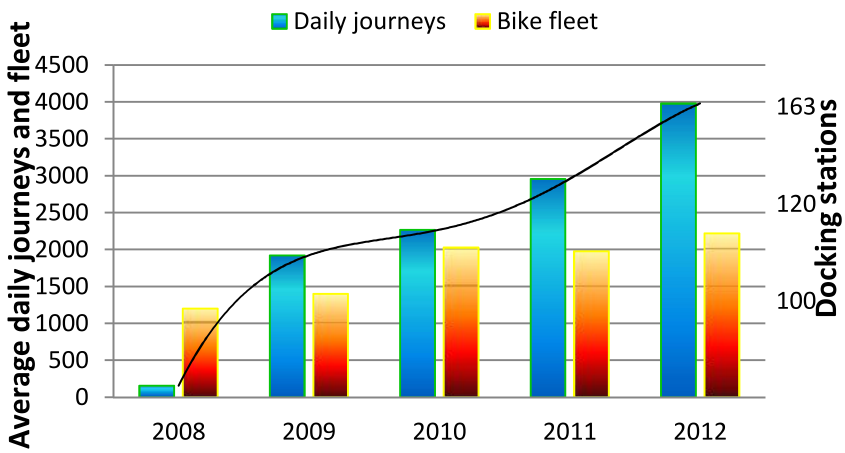


Figure 2 - Number of daily journeys and stations (2008-2012). The black line represents the number of available stations. Data for 2008 are only for December

3. THE AVERAGE *BIKEMI* USER AND HER/HIS CYCLING BEHAVIOUR

The form used for the *BikeMi* subscription request contains questions about some users' personal details. According to the data resulting from the answers to these questions, the average profile of a *BikeMi* user is a 41 year old, male professional, who uses the *BikeMi* bicycle to go to work for the last mile of his daily commuting journey (Figure 3).

61.6% of the subscriptions are men, and 48.4% women. Male users' average age is 42 years, female users' average age is 38 years. The majority of subscribers are managers or consultants/entrepreneurs (26.53% of managers among male respondents and 19.87% among female respondents; percentages are a little higher for consultants/entrepreneurs – see Figure 3). Students are 5.88% of the customers, whereas pensioners are only 1.66%. Figure 4 shows the users' distribution according to their current postcode. It can be noted that the service attracts a high percentage of commuters (more than 25%) outside the Milan urban area.

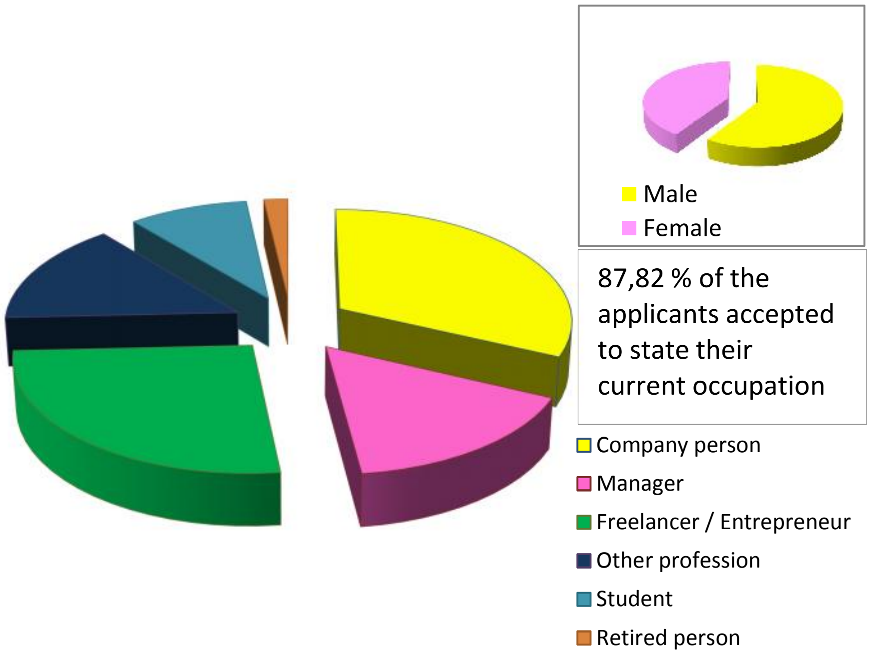


Figure 3 - BikeMi users' characteristics (2008-2012)

Figure 4 - Users' current residential address distribution (Dec. 2008-2012)

During peak periods the bike traffic converges more intensively towards docking stations situated in central areas. Peak-period traffic has increased more than other day periods during the years (Figure 5). Three peaks can be noticed: the first one is at 8AM with more than 250,000 journeys in 2012; the second one at 1PM with almost 140,000 journeys in 2012 and the third one at 6PM with almost 200,000 journeys in 2012.

On average, in 2013 each bicycle was used almost twice a day, whereas it was used only once a day in 2010 (Figure 6).

The most important stations in terms of usage are those in the very city centre (see again Figure 1) where pedestrian areas are located. The stations in Duomo square, Cadorna square and San Babila square (all central locations) have registered more than 20,000 check-ins in 2010 (area in red in Figure 1). Other areas near these central locations situated in transport interconnection points (areas in yellow in Figure 1) registered between 10,000 and 20,000 check-ins in 2010. Other important locations are those near the main railway stations.

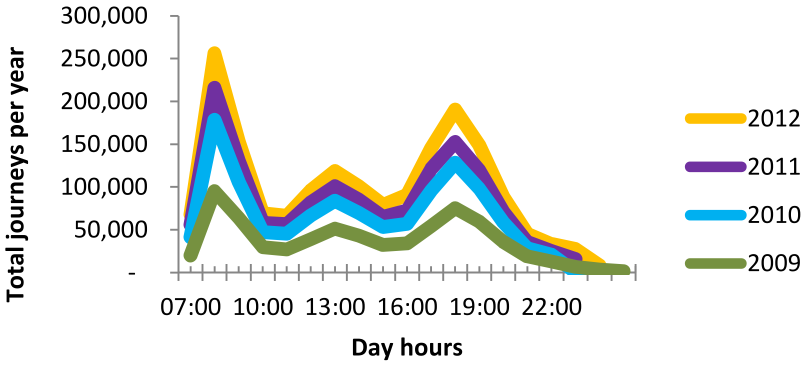


Figure 5 - Total number of journeys per period of the day (2009-2012)

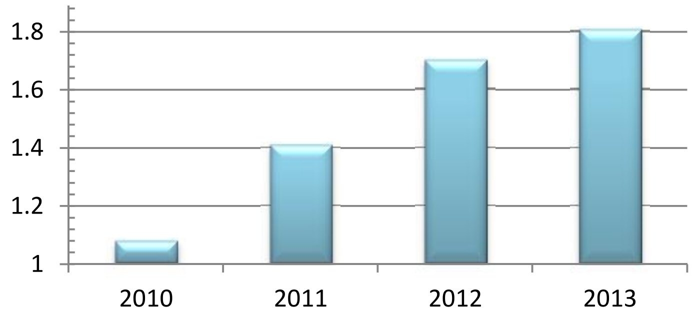


Figure 6 - Average daily journeys for each bicycle (2010-2013)

4. SPEED AND CYCLING ITINERARIES

The available dataset allows for a thorough analysis of cycling speed[4] and users' preferred itineraries. During winter, cyclists' average speed reaches higher values than during warmer months. Figure 7 shows the cyclists' main patterns of travel which often result to be in correspondence of pedestrian paths and bus/tram lanes. Many of these paths are along the wrong direction of one-way streets therefore suggesting that cyclists use sidewalks intensively all around the three main city centre traffic hubs: San Babila square, Duomo square and Cadorna square. Travel destinations are concentrated in the Milan congestion charge area or close to its boundaries and in city neighbourhood lacking underground and other main public

[4] No speedometer or distance counters is mounted on *BikeMi* bikes. In our analysis, the distance of a bike trip is estimated with the use of some software applications. The GPS coordinate position of each bike station is determined through Google online services, namely the "Google Distance Matrix API" service that provides travel distance and time for a matrix of origins and destinations by returning an XML report of the results, which, through a C++ string, is sent to a matrix-like dataset, which is finally stored in a CSV file.

transport facilities. Short journeys within 500 meters from the starting point (journeys are often included within 2 km) are numerous, probably as an alternative to walking. The average walking distance to find a car park in central Milan is in the order of 200m which is similar to that of the closest *BikeMi* station, but finding a car park space is also generally more difficult than finding an empty *BikeMi* slot. The combination of these elements may explain the doubling of the number of *BikeMi* cyclists since the start of the scheme. These findings are of great importance, considering that these bike paths are often along streets prohibited to cars due to the congestion charge and that practically there is no waiting time for parking.

Speed is an important quantitative factor in the evaluation of the efficiency of a transportation system. Maximum speeds, achieved by a few individuals, are always between 19 and 24 km/h average, with peaks levels of 27 km/h in the morning periods. Indeed, highest speeds are reached almost always in the morning, when customers are in a hurry to get to their workplace, more than when they have to return home in the evening. Thence, although the overall average speed is 9 km/h, the upper decile is over 12 km/h (Figure 8). In the morning rush hours, cyclists' average speeds - in normal conditions and for average users - is 13.5 Km/h. These average speeds are close to those of other European cities, and in many cases lower than those of cities of similar dimension. For example, for Lyon, France, the averages are around 18 Km/h and 12 Km, respectively (Jensen et al., 2010), but Milan has one of the world's highest rate of car ownership, is one of Europe's most polluted cities and has one of the lowest average car speed (22 Km/h for the whole urban area which comprises highways, according to the last report commissioned by ANCI, the Italian Association of City Councils (Cittalia, 2009)). During weekdays, in months with the highest bicycle usage (i.e. September and October), the average speed reaches about 10 km/h and the upper decile is more than 13.5 km/h. Cyclists' average speed reaches a peak of 9.5 km/h during the early hours of weekday mornings, when the traffic flow is more fluid. When there is less need to hurry, the average speeds fall to 8 km/h as in weekends and afternoons.

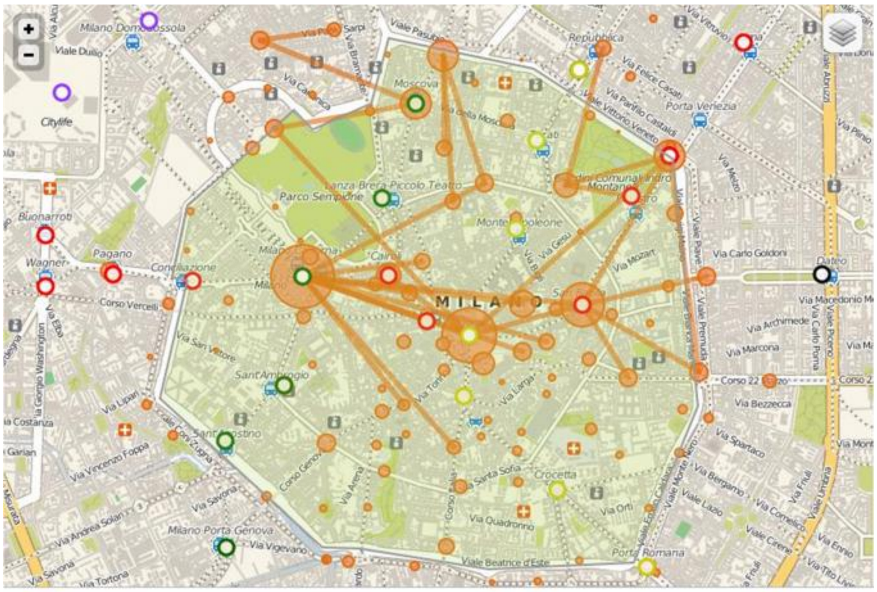


Figure 7 - Main cycling paths (highlighted in orange). The radius of the orange circles around the stations are proportional to the total number of trips. Other circles in red, light green and dark green represent Milan's underground stations. The light green area is the congestion charge area (Source: 2012, Clear Channel dataset and pedalami.it website)

Bike traffic is therefore an important component of nowadays urban transportation systems. Strategies to reinforce these systems can be adopted by first of all considering the number of docking stations with no bicycles available as well as users' main paths.

If journey data do not provide sufficient details about specific routes taken by customers, on the other hand distances and usage time can be easily calculated through hire and drop-off points information.

From these data it appears that commuters use the *BikeMi* bicycles to move over around 300 meters on average, while they hardly travel longer distances. Furthermore, most of the journeys are shorter than 30 minutes (Figures 8, 9, 10).

Figures 9 and 10 also show the distances carried by users, and the journeys' time lengths. It can be noted (Figure 11) that the *BikeMi* usage grew consistently over the years. The majority of users (97.4%) use the bicycle for a period less than half an hour due to the additional charge above 30 minutes, while only a fraction of them use the bicycle for longer periods. However, journey data do not provide details about specific routes and personal behaviour by customers. Therefore, in the future, a customer care survey should be implemented, in order to explore and learn more about user's behaviour.

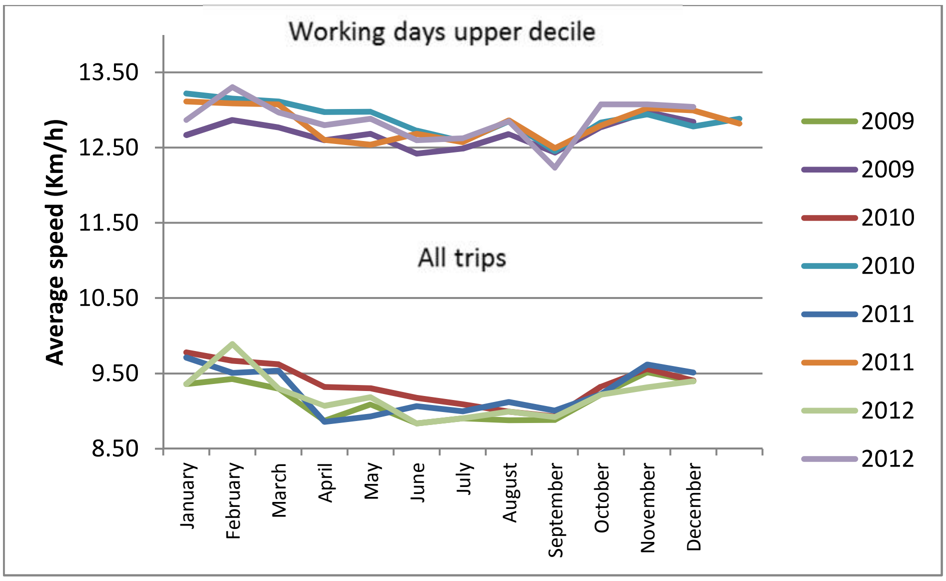
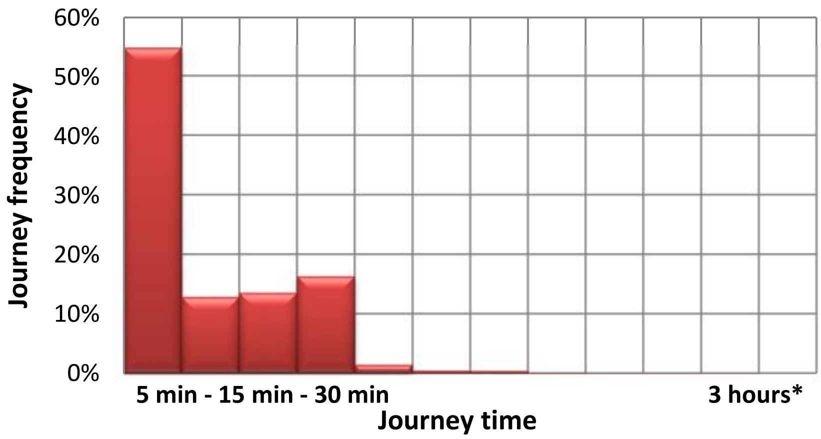


Figure 8 – Monthly Average speed on weekdays and for all trips (2009-2012)

Figure 9 - BikeMi distance frequencies during the warm season (2009-2012)



** Journeys longer than 3 hours are excluded being users wrongdoings in checking outs.*

Figure 10 - BikeMi renting time length during the warm season (2009-2012)

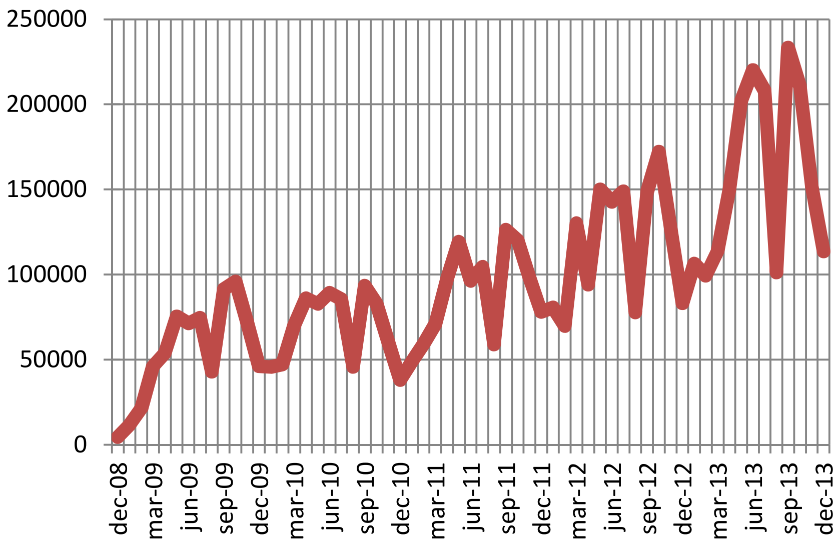


Figure 11 - BikeMi total journeys (2009-2013)

5. DETERMINANTS OF THE BIKE USAGE

In this section our purpose is to model counts of bike check-ins and check-outs throughout the docking stations inside the Spanish walls (also called “Bastioni”, centred in the Duomo square – around 8.2 Km^2, about 4.5% of the whole Milan municipality area), in order to find the most important associations between bike usage and public transport characteristics of the areas where docking station are situated.

We chose the “Bastioni” area since it corresponds to the traffic restricted zone introduced in Milan since January 2008. We model counts separately at each hour of the day[5] and separately for check-ins and check-outs from 7AM to 8PM, resulting in twenty-six distinct models. This hourly analysis allows to check for time pattern of usage during the day. Predicting variables chosen to explain the counts variability are: (i) the presence of a railway station in the vicinity (1 if present, 0 otherwise); (ii) the number of underground lines; (iii) the number of bus lines; (iv) the number of tram lines; (v) the distance in Km from Duomo square; (vi) the suburb location (1=Northern area; 0=Southern area). Counts were those of May 2010 which is almost in the middle of the three-year period to which the dataset is referred and can be well representative of a fully working period with no other festivities and no other particular events influencing the normal usage.

Table 1 presents some station characteristics in terms of distance from the city centre (ranging from 0 to 2 Km) and suburb location (15 stations out of 19 are situated in the northern area), together with average counts of bike check-ins and check-outs across three-hour intervals in May 2010. The maximum check-in value occurs in Porta Venezia (where one railway station,

[5] We excluded Saturdays and Sundays.

two underground lines, five tram lines and one bus line are located – see Table 2 for details of the number of public transport lines in docking stations' neighbourhood) at 5-8PM (33.13 average count). The maximum check-out value occurs in Cadorna (having one railway station, two underground lines, two tram lines and four bus line in the immediate vicinity) at 7-10AM (53.78 average count).

5.1 Poisson regression model on bike check-ins and check-outs

Poisson regression is one of the most important regression methods to model count data (Cameron and Trivedi, 2013). The assumption is that counts y_i (i.e. the number of occurrences of the event of interest for the *i*-th observation – in our case the number of check-ins and check-outs) are Poisson-distributed given the vector $\mathbf{x}_i$ of linearly independent regressors that explain the variability in y_i. For each *i* of *n* observations the basic Poisson model gives the distribution of y_i given $\mathbf{x}_i$:

$$f(y_i|\mathbf{x}_i) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!} \qquad (1).$$

The mean parameter μ_i is such that $E[y_i|\mathbf{x}_i] = \mu_i$. In the log-linear version the mean is parameterized as follows, with $\boldsymbol{\beta}$ representing the vector of the regression coefficients:

$$\mu_i = exp(\mathbf{x}_i'\boldsymbol{\beta}) \qquad (2).$$

Equations (1) and (2) simultaneously define the Poisson regression model.

5.2 Results

Table 3 reports the results of the Poisson regression analysis. The sign of the variable representing the presence of a railway station variable is always positive (apart from check-ins in the 7AM-8AM period) and significant (apart from check-outs at 5PM-6PM). Moreover, from early hours to late hours the magnitude of its coefficients increases for check-ins and decreases for check-outs. This means that the service is used mainly by commuters from outside Milan arriving in the morning and leaving in the evening, confirming the fact that *BikeMi* service is strongly used not only by Milan residents but also by Lombardy region residents (see Figure 4) intending to reach working sites near the railway stations.
Surprisingly, other transportation modes have a negative effects on the usage of the service. This can be justified by the fact that Milan has one of the best underground network in Italy with four lines and other 10 suburban train lines, and also good bus and tram networks. Therefore, a widespread transport service is available for the users in the city centre, and cycling is still too far to be a successful competitor in this sense. As expected, bike usage is higher as the distance from the city centre increases and in the northern part of the city.

Table 1 – Location and spatial characteristics of stations, bike check-ins and check-outs average working day hourly counts

Period: May 1st, 2010-May 31st, 2010						
Station characteristics			*Average hourly counts (first row: check-ins; second row: check-outs)*			
Docking station	**Distance to the city centre (Km)**	**Suburb location**	**07:00-10:00**	**12:00-15:00**	**17:00-20:00**	**07:00-20:00**
Duomo	0	North	15.21	9.65	29.52	10.24
			6.21	11.54	17.16	10.08
San Babila	0.75	North	11.77	8.61	7.22	8.30
			6.01	9.26	13.70	8.46
Cadorna	1.26	North	4.81	8.83	28.61	12.19
			53.78	7.57	5.94	17.32
Corso Italia	1.45	South	6.01	3.54	4.06	3.82
			4.25	3.52	5.96	3.86
Sant'Agostino	1.99	South	4.52	2.57	5.57	2.76
			5.33	2.71	2.25	2.97
Arco della Pace	2.00	North	2.68	3.42	7.49	3.74
			7.64	3.19	4.04	4.27
Regina Margherita	1.92	South	0.70	1.25	3.10	1.55
			3.04	3.70	4.17	1.61
Cinque giornate	1.64	South	3.35	3.64	5.83	3.85
			4.32	3.06	4.13	3.51
Tricolore	1.59	North	2.19	3.42	5.88	3.49
			6.54	3.67	3.51	3.98
Porta Venezia	1.88	North	2.94	4.91	33.13	5.45
			10.10	4.12	4.64	5.61
Moscova	1.66	North	3.87	4.41	5.91	4.23
			5.13	4.52	5.75	4.52
XXV Aprile	1.95	North	2.41	3.01	10.04	4.35
			11.94	3.35	4.26	5.15
Cadorna 2	1.24	North	1.45	1.62	7.23	2.91
			9.48	1.29	1.71	3.27
Brera	0.95	North	5.36	2.84	3.93	3.33
			1.97	3.51	5.12	3.09
Fatebenefratelli	1.22	North	8.15	2.45	1.59	3.32
			1.83	2.88	5.93	2.91
Cavour	1.17	North	7.99	4.48	2.45	4.23
			1.30	4.75	7.01	3.77
Meda	0.52	North	9.78	4.54	3.01	4.79
			0.77	5.61	8.86	4.46
Cusani	0.63	North	6.42	3.07	1.57	2.98
			1.07	3.17	5.59	2.78
Cairoli	0.70	North	4.17	4.35	4.33	3.92
			3.39	4.25	5.45	3.89

Note: for each station the average counts for check-ins are displayed in the first row, the average counts for check-outs are displayed in the second row.

Table 2 – Station connections with other public transport facilities (such as tram, bus, underground, railway stations, airport shuttle, touristic bus)

Docking station	No. of tram lines	No. of bus lines	No. of underground lines	Rail stations	Other facilities	Total
Duomo	7	0	2	0	0	9
San Babila	0	7	1	0	0	8
Cadorna	2	4	2	1	1	10
Corso Italia	5	3	0	0	0	8
Sant'Agostino	2	1	1	0	0	4
Arco della Pace	5	4	0	0	0	9
Regina Margherita	3	3	0	0	0	6
Cinque giornate	4	4	0	0	1	9
Tricolore	2	3	0	0	1	6
Porta Venezia	5	1	2	1	1	10
Moscova	2	2	1	0	0	5
XXV Aprile	1	1	3	1	1	7
Cadorna 2	2	4	2	1	1	10
Brera	4	2	1	0	0	7
Fatebenefratelli	3	0	1	0	0	4
Cavour	1	3	2	0	0	6
Meda	1	7	1	0	1	10
Cusani	7	6	1	0	1	15
Cairoli	7	6	1	0	1	15

Table 3 – Poisson regression coefficients on bike average check-ins and check-outs (restricted sample)

						Check-ins							
						Hours							
Independent variables	*7-8*	*8-9*	*9-10*	*10-11*	*11-12*	*12-13*	*13-14*	*14-15*	*15-16*	*16-17*	*17-18*	*18-19*	*19-20*
Intercept	3.43***	6.22***	6.33***	5.651***	4.64***	5.02***	5.25***	5.87***	5.57***	5.76***	6.15***	6.37***	6.35***
Railway station	-0.46**	0.08	0.28***	0.53***	0.41***	0.64***	0.75***	1.54***	1.75***	2.20***	2.81***	2.55***	2.36***
Under. lines	0.54***	-0.04	-0.22***	-0.21**	-0.08	-0.06	-0.12**	-0.36***	-0.44***	-0.42***	-0.46***	-0.64***	-0.71***
Bus lines	-0.01	-0.03***	-0.05***	-0.05***	-0.02	0.02	-0.02	-0.03**	-0.03**	-0.03**	-0.02	-0.05***	-0.09***
Tram lines	-0.06**	-0.09***	-0.07***	-0.06***	-0.03**	-0.04***	-0.04***	-0.06***	-0.07	-0.09***	-0.12***	-0.07***	-0.05***
Distance	-0.93***	-1.07	-0.99***	-1.08***	-0.57***	-0.65***	-0.64***	-1.03***	-0.85***	-1.11***	-1.14***	-0.75***	-0.64***
Sub.loc. (1=North)	0.85***	0.70***	0.48***	0.23**	0.39***	0.13	0.54***	0.45***	0.42***	0.45***	0.40***	0.29***	0.14**
N	18	18	18	18	18	18	18	18	18	18	18	18	18
Deviance	114.6	399.6	357.2	174.3	148.2	182.0	269.9	206.5	250.0	327.9	473.7	645.2	518.7
						Check-outs							
						Hours							
Independent variables	*7-8*	*8-9*	*9-10*	*10-11*	*11-12*	*12-13*	*13-14*	*14-15*	*15-16*	*16-17*	*17-18*	*18-19*	*19-20*
Intercept	5.85***	7.91***	6.66***	5.86***	4.54***	5.73***	5.89***	5.04***	4.74***	5.32***	5.35***	6.01***	6.02***
Railway station	4.58***	4.18***	3.02***	2.36***	0.88***	0.80***	0.93***	0.52***	0.66***	0.78***	-0.01	0.19*	0.73***
Under. lines	-1.40***	-1.19***	-0.83***	-0.65***	-0.15*	-0.09	-0.24***	-0.07	-0.19**	-0.25***	0.11*	-0.02	-0.14**
Bus lines	-0.07**	-0.09***	-0.06***	-0.08***	0.01	-0.05***	-0.03**	-0.02	-0.02	-0.03***	0.01	-0.04	-0.04***
Tram lines	-0.23***	-0.20***	-0.10***	-0.09***	-0.03**	-0.08***	-0.08***	-0.03**	-0.02*	-0.04***	-0.06***	-0.06	-0.06***
Distance	-1.02***	-1.18***	-0.98***	-1.09***	-0.57***	-1.01***	-0.96***	-0.62***	-0.60***	-0.75***	-0.75***	-0.89***	-1.05***
Sub.loc. (1=North)	0.82***	0.27***	0.32***	0.38***	0.43***	0.39***	0.54***	0.52***	0.61***	0.34***	0.43***	0.47***	0.51***
N	18	18	18	18	18	18	18	18	18	18	18	18	18
Deviance	480.3	1427.7	666.3	162.7	161.7	117.5	180.2	197.2	212.6	178.0	222.9	284.3	232.1

Table 4 – Poisson regression coefficients on bike average check-ins and check-outs (whole sample)

	Check-ins												
	Hours												
Independent variables	*7-8*	*8-9*	*9-10*	*10-11*	*11-12*	*12-13*	*13-14*	*14-15*	*15-16*	*16-17*	*17-18*	*18-19*	*19-20*
Intercept	2.64***	4.98***	4.59***	4.36***	4.40***	4.40***	4.92***	4.67***	4.14***	4.14***	3.77***	4.43***	4.77***
Slots	-0.03***	0.01***	0.02***	0.02***	0.00	0.01*	-0.00	-0.01**	0.00	0.01	-0.02***	-0.02***	-0.03***
"Navigli"	0.71***	0.30***	0.17***	-0.23***	-0.05	-0.10*	0.14***	0.42***	0.21***	0.33***	0.83***	0.54***	0.27***
Congestion	-0.20*	-0.25***	-0.16***	-0.45***	-0.57***	-0.38***	-0.49***	-0.44***	-0.44***	-0.48***	-0.28***	-0.41***	-0.32***
Railway station	-0.83***	-0.64***	-0.59***	-0.54***	-0.35***	0.64***	-0.20***	-0.06***	0.08	0.39***	0.70***	0.34***	0.32***
Under.lines	0.23***	0.05***	-0.02	0.07**	0.09***	0.05**	0.09***	0.04*	0.01	0.10***	0.14***	0.06***	-0.06***
Bus lines	0.03***	0.02***	0.01***	0.04***	0.02**	0.01*	-0.01**	-0.00	-0.01	-0.01*	-0.02***	-0.04***	-0.06***
Tram lines	0.06***	0.00	-0.00	-0.02	-0.01	-0.01	-0.01	-0.02***	-0.02***	-0.04***	-0.07***	-0.03***	-0.01
Distance	-0.23**	-0.70***	-0.62***	-0.81***	-0.64***	-0.50***	-0.54***	-0.43***	-0.40***	-0.41***	0.13**	0.22***	0.21***
Sub.loc. (1=North)	0.78***	0.44***	0.43***	0.31***	0.43***	0.28***	0.43***	0.47***	0.49***	0.31***	0.37***	0.42***	0.24***
N	99	99	99	99	99	99	99	99	99	99	99	99	99
Deviance	1178.6	2958.9	2476.2	1051.9	906.8	1227.1	1676.9	1507.1	1415.8	2094.5	3674.8	4657.48	3935.7
	Ckeck-outs												
	Hours												
Independent variables	*7-8*	*8-9*	*9-10*	*10-11*	*11-12*	*12-13*	*13-14*	*14-15*	*15-16*	*16-17*	*17-18*	*18-19*	*19-20*
Intercept	1.87***	4.42***	4.41***	4.48***	4.68***	4.92***	4.78***	4.73***	4.53***	4.46***	4.27***	4.95***	4.84***
Slots	-0.04***	-0.05***	-0.04***	-0.01*	-0.01*	-0.02***	-0.00	-0.00	-0.00	0.00	0.01***	0.01***	0.01*
"Navigli"	1.40***	1.17***	0.73***	0.11*	-0.12*	0.16***	0.28***	-0.09*	-0.04	-0.00	0.28***	0.25***	0.14***
Congestion	0.26***	-0.07**	-0.03	-0.40***	-0.50***	-0.32***	-0.38***	-0.37***	-0.38***	-0.42***	-0.24***	-0.48***	-0.47***
Railway station	0.93***	0.93***	0.56***	0.19***	-0.11*	-0.27***	-0.27***	-0.27***	-0.24***	-0.29***	-0.43***	-0.37***	-0.35***
Under.lines	0.06***	-0.03**	-0.09***	-0.00	0.02	0.04	0.04*	0.12***	0.00	0.06**	0.02	0.01	0.09***
Bus lines	-0.07**	-0.06***	-0.05***	-0.02**	0.03***	0.02***	0.02***	0.01	0.01	0.01*	0.01	0.00	0.01**
Tram lines	-0.08***	-0.07***	-0.02***	-0.03***	-0.01	-0.02**	-0.02***	0.01	0.01	0.01*	0.01**	0.01	-0.00
Distance	1.08***	0.67***	0.37***	-0.33***	-0.59***	-0.50***	-0.53***	-0.60***	-0.50***	-0.51***	-0.48***	-0.56***	-0.64***
Sub.loc. (1=North)	0.30***	0.29***	0.32***	0.23***	0.34***	0.33***	0.53***	0.39***	0.40***	0.29***	0.46***	0.53***	0.48***
N	99	99	99	99	99	99	99	99	99	99	99	99	99
Deviance	3355.1	11146.2	4382.8	1363.3	1072.9	1412.4	1615.8	1377.1	1047.3	1023.6	1690.6	2034.0	1879.8

*Note: *p<0.10; **p<0.05; ***p<0.01.*

6. CONCLUSION AND FUTURE WORK

This paper has shown that the Milan PSBS has steadily grown during the last years, doubling the average daily bike usage, while the bike fleet, as well as the number of docking stations available, has also increased. One of our main research goal was to detect the most common bicycle paths and analyse the bike journey average speed.

This analysis has also shown that PSBS is a fast and convenient option for short-distance trips in cities, and can play an important role in reducing urban mobility problems in multiple contexts. It can also provide efficient first-last mile connections and end-to-end trips.

Possible policies to promote cycling include the improvement of a safe cycling infrastructure together with the empowering of technical facilities like electronic docking station services and new bike accessories. With the improvement of the service quality, commuting speed and the total amount of distance covered should consequently increase. PSBSs should also contribute to the general efficiency of cycling, which in turn helps improving the urban transportation route structure and reduces carbon emissions, alleviates traffic congestion problems and carries out a sustainable development strategy for urban transportation.

In conclusion, citizens of Milan are increasingly getting used to urban cycling due to this new transport system. Consequently, city council investments in designing bike paths should result improved, having a positive impact on the safety and promotion of bike sharing.

Cyclists' risk perception and weather conditions affect their behaviour. One of our next step will be the analysis of results from a customer care survey recently carried out in order to understand users' behaviours, perception of the PSBS quality and commuters' needs. Preliminary results from this surveys shows interesting features regarding the preference of customers. For example, the introduction of pedal-assisted bikes would favourably be welcomed by customers, with almost 40% even willing to pay more for this.

Future research into PSBSs operating in big cities like Milan, might preferably include the analysis of existing urban planning, such as pedestrian-cycle reserved tracks or commuters facilities for daily bicycle usage. There is already a huge amount of research which deals with topics like the quality of facilities, safety and environment improvements from SBSs. These studies reveal the existence of several issues, which could be investigated further, so as to obtain a more comprehensive picture of the complexities related to development of these transport schemes. New instruments like data mining analysis and relatively new methodologies like meta-analysis should be used in order to dig into the evidence and help urban planners to make prompt decisions for a balanced development. Some improvements of the modelling of bike counts is also needed. First, the analysis should be extended to the entire parking lots and urban areas and the dichotomous variable "congestion charge area" should be introduced among the independent variables. The effect of the 30-minute free bike renting should also be fully investigated. Second, rather than modelling using stations as observations, an analysis with days as observations and meteorological variables and other time-dependent determinants like fuel prices or the number of strikes or public area restrictions should be considered in order to predict future bike usage.

Another issue to be further analysed is the *BikeMi* business model which seems to be very successful for all the actors involved: the city council, the advertising company and ultimately the final customers. Accordingly, future research regarding shared bicycle systems should concentrated on examining the potential of advertising for the procurement of public transport services to private companies as well as non-profit business models, such as cooperatives and citizens associations, capable of managing the PSBS in little towns and villages.

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