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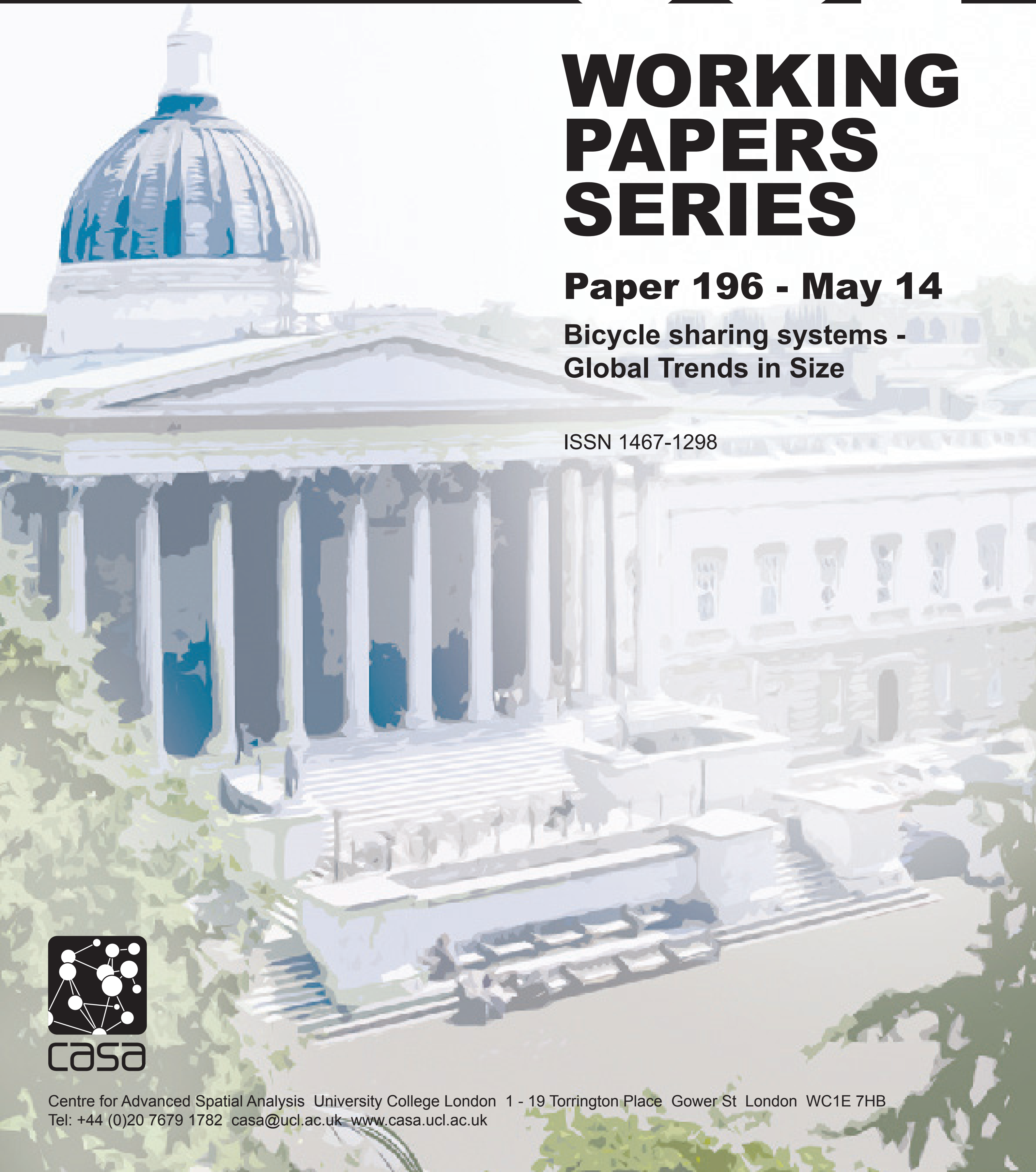

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Bicycle sharing systems - Global Trends in Size

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Bicycle sharing systems – Global Trends in Size (May 2014 Research Update)[1]

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Abstract

Bicycle sharing systems allow users to hire a bicycle from an automated docking station for short journeys, typically one-way, providing a novel alternative to traditional methods of transport. The adoption of such systems by cities has been accelerating, with over 700 active systems as of early 2014, an increase of around 50% in a year. UCL CASA has been observing a number of the larger systems since 2010, and collecting data on their size in terms of numbers of docking stations and bicycles. This paper shows that, for many larger cities, their existing systems have grown in size organically or on a phased basis, by area expansion and/or intensification, during the period of study, although some systems have decreased in size.

Keywords: bikesharing, bicycle sharing, BSS, urban cycling, cities, docking station

1. Introduction

Bicycle sharing systems allow users to take short, one-way cycle trips, generally in urban locations. So-called third generation systems (Shaheen et al 2010), studied here, are operated using automatic kiosks situated at a number of docking stations throughout a system area, using a credit card or account key. Bikes are released electronically from a docking point in the station, and returned to a similar docking point in another station.

Third generation systems first appeared in the mid to late 2000s, with Lyon and Barcelona being amongst the earliest (Lebetkin 2013). Such systems typically have a public website, allowing users to learn how to use the system, register for membership, and see the available locations on an online map. Near-live information is often included on the map, so that the user can see whether their local docking station has bikes available, and, just as importantly, that their intended destination has empty docking points.

The number of systems has grown rapidly in the last ten years and it is estimated that there are currently just over 700 systems in active use (Meddin and DeMaio 2014), up from approximately 450 a year ago (Austwick et al 2013). An online map (Meddin and DeMaio 2014) plots all known systems, showing their status (proposed, active, retired) and including information on their size (number of docking stations and bikes in the system), typically obtained from press releases, media coverage of the system, or using statistics available on the operator website. The smallest systems have just a single docking point, typically at a railway station, and are designed for all-day use by a visitor, while the largest systems have more than 1000 docking stations and 20000 bikes available for use. A small number of systems, such as the Ruhr Valley (Germany), Bay Area (San Francisco), and a number of Chinese systems, stretch across a wide region. In the case of the Ruhr Valley, the system is designed for travel between towns, whereas other such systems are linked together purely for operational purposes and, in terms of

[1] Original publication date: 6 May 2014.

journeys typically made, likely act as if they were multiple discrete systems, with clusters of docking stations each serving a separate town, city or urban district.

2. Method of data collection

Many systems make their data available online through a map, and/or through an API. This data includes statistics on individual docking stations, showing the operational capacity of each docking station and/or the number of bikes currently in it. The total size of the system can therefore be simply calculated by looking at the number of docking stations, and the typical daily maximum number of bikes available in them (which often occurs shortly after midnight, when a system's use is normally lowest).

The data also typically includes coordinates of the docking stations, allowing spatial analysis to be performed on them, for example to calculate the effective system area, docking station density, entropy of distribution and other characteristics. Such data is not studied for this paper, which concentrates on the total numbers for each system. Analyses looking at location or diurnal fluctuations have been performed in a number of other papers (Côme and Oukhellou 2012, Borgnat et al 2013, O'Brien et al 2013, Goodman and Cheshire 2014) and research is ongoing.

3. Summary of systems analysed

We aim to incorporate as many systems as practically possible into our ongoing study of bicycle sharing. The primary aim is to spatiotemporally analyse such systems. As such, small systems (with less than ten docking stations) are generally disregarded, because their constrained extent means they are unlikely to show significant spatial patterns in their day-to-day use. Systems where live information on both available bikes and free docking points is not available are also not included, as this data is necessary to carry out typical spatiotemporal analysis work which forms the main part of our research.

We visualise systems which are being analysed on a website[2] which acts as a near-live map of each system, showing docking stations as circles of varying sizes and colours, based on the docking station size and ratio of the number of bicycles to empty spaces at each station, respectively. An example system is shown in Figure 1.

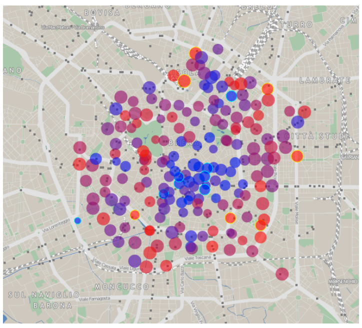

Figure 1: *Example view of the map of nearly live docking station information, extracted for analysis. The system shown here is Milan, on a weekday evening, following the end of most commercial and tourist activities for the day. The centre of the system shows predominately blue-coloured circles, indicating docking stations that are nearly empty. Red colours show that the opposite is true on the edge of the system's footprint.*

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2 http://bikes.oobrien.com/

Additionally, the data needs to be freely accessible over the web. A number of systems do not have the data available, or employ techniques to limit the necessarily automated and repeated retrieval of the data, such as requiring each individual docking station's data to be requested separately and then building a delay between the data being requested and transmitted (e.g. Antwerp), or converting the data to an image before displaying it (e.g. Changshu, as shown in Figure 2).

Figure 2: *Screenshot of the operator's online map for Changshu (China), which started to obfuscate the bikes/empty spaces data for individual docks by displaying them as automatically distorted images, several months after the data started to be collected. The overall number of docks can still be observed.*

A number of large systems are therefore not studied by CASA and so do not appear in this study. Most of the systems affected are in China, including around three-quarters of what are believed to be the 20 largest systems in the world (ITDP 2014). It is believed that almost all large systems (greater than approximately 100 docking stations) outside of China are however included here.

For expediency of analysis we have taken a sample of 46 of the approximately 110 systems currently being analysed by CASA, including many of the larger systems and a number of smaller ones too, across multiple continents, as shown in Table 1. Where many systems have been available in a single region, we have chosen those for which we have data across a wide timespan. CASA is working with a number of operators and hopes to publish a similar analysis for a wider number of cities in the future, as new sources are acquired and data continues to be accumulated.

Continent	Number of Systems	Average Number of Docking Stations per System
Asia	9	126
Europe	18	239
Latin America	4	99
Middle East	1	158
North America	12	125
Oceania	2	99
Total	**46**	**167**

Table 1: *Summary of geographical distribution of systems included in this analysis.*

4. Results

The systems were measured on a biannual basis between October 2010 and April 2014.

Some systems have data missing for some months. This is because the data was unavailable for capture at this time (the system may not have launched or the data may not have been available), or CASA may not have been aware of the system and so collection had not commenced. In some cases, some systems are suspended during some months of the year, typically during winter.

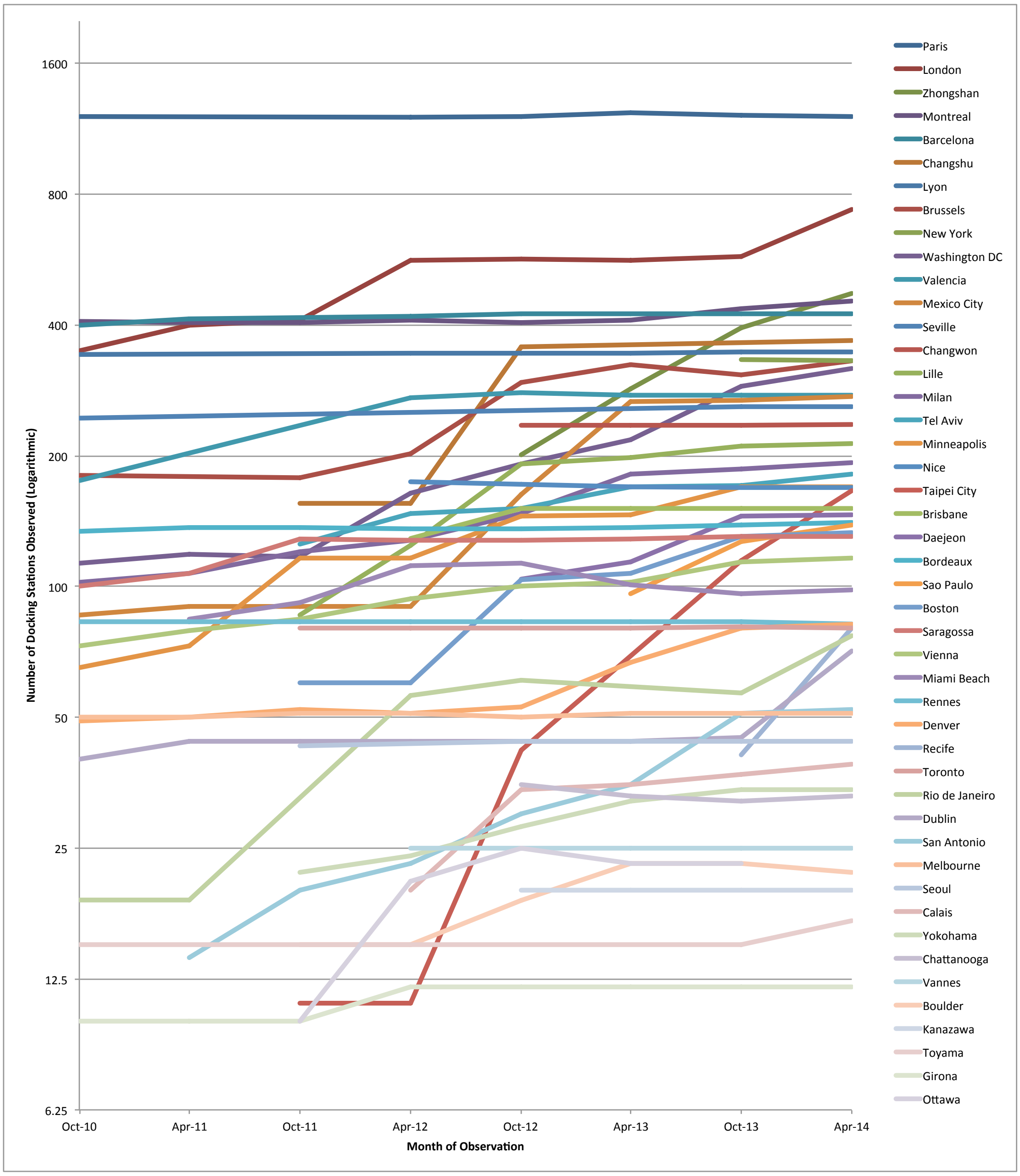

Figure 3: *Changes in numbers of docking stations observed, across 46 cities that have medium or large bicycle sharing systems. The maximum number of docking stations present in the system, during a month, was measured every six months. The order of the key matches the values on the right hand side of the chart (April 2014). Please note that the vertical scale is logarithmic, moving up across the space between each gridline represents a doubling in size.*

The two measurements made are of the maximum number of bicycles available for use and the maximum number of docking stations in the system. In most cities, the ratio of bicycles available to docking stations remains approximately constant through the measuring period. Taipei City, Changshu and Milan are notable exceptions.

In the last year a significant number of systems have increased in size, as shown in Table 2.

City	Continent	Change
Zhongshan, China	Asia	65.7%
Dublin, Ireland	Europe	61.4%
San Antonio, USA	North America	48.6%
Washington DC, USA	North America	45.9%
São Paulo, Brazil	Latin America	44.8%
London, UK	Europe	31.0%
Rio de Janeiro, Brazil	Latin America	30.5%
Daejeon, South Korea	Asia	28.1%
Boston, USA	North America	24.3%
Denver, USA	North America	22.4%
Minneapolis, USA	North America	16.4%
Vienna, Austria	Europe	13.7%
Calais, France	Europe	11.4%
Montreal, Canada	North America	11.0%
Lille, France	Europe	7.6%
Tel Aviv, Israel	Middle East	6.5%
Yokohama, Japan	Asia	6.3%
Milan, Italy	Europe	6.0%
Brussels, Belgium	Europe	2.5%
Mexico City, Mexico	Latin America	2.2%
Bordeaux, France	Europe	2.2%
Saragossa, Spain	Europe	0.8%
Changwon, South Korea	Asia	0.4%
Lyon, France	Europe	0.3%
Barcelona, Spain	Europe	0.0%
Valencia, Spain	Europe	0.0%
Brisbane, Australia	Oceania	0.0%
Toronto, Canada	North America	0.0%
Melbourne, Australia	Oceania	0.0%
Seoul, South Korea	Asia	0.0%
Chattanooga, USA	North America	0.0%
Vannes, France	Europe	0.0%
Kanazawa, Japan	Asia	0.0%
Girona, Spain	Europe	0.0%
Nice, France	Europe	-0.6%
Rennes, France	Europe	-1.2%
Paris, France	Europe	-1.6%
Miami Beach, USA	North America	-3.0%
Boulder, USA	North America	-4.3%
Ottawa, Canada	North America	-100.0%

Table 2*: Percentage change in numbers of docking stations for cities in this study, based on observations during April 2013 and April 2014. Cities where data was not collected for April 2013 have not been included in the table.*

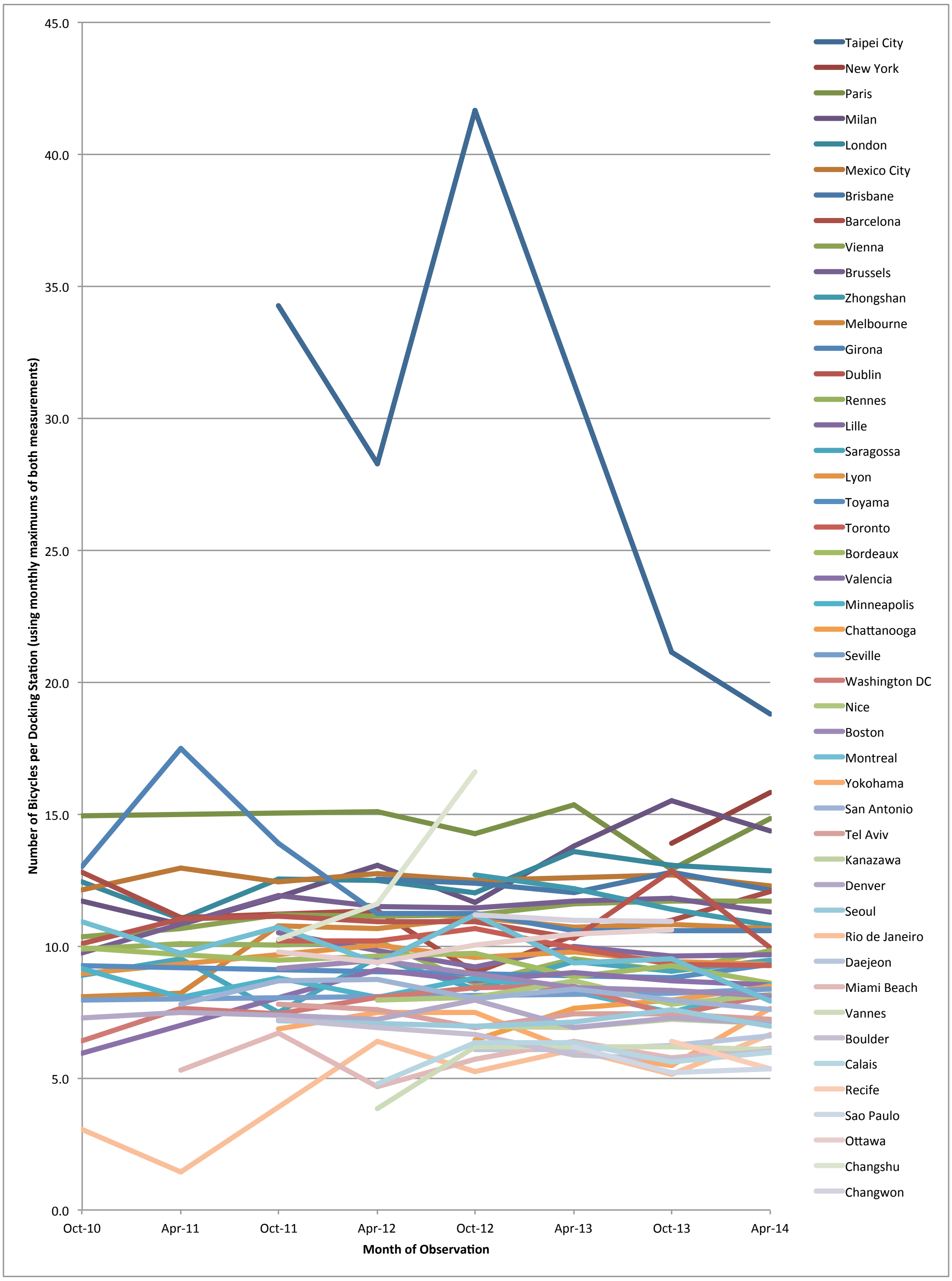

Figure 4: *Variation of maximum bike to docking station ratio across the time period of the study. This was calculated by dividing the maximum measured number of bikes by the maximum measured number of docking stations during each month of observation. The order of the key matches the values on the right hand side of the chart (April 2014).*

A table of numbers of docking stations and bicycles is presented in Appendix 1, from which the above graphs and tables are derived.

5. Discussion

Figure 3 shows a number of trends, across the cities being studied. Paris, by far the largest of the systems studied, has remained almost constant in terms of numbers of docking stations or bicycles, recently. London's system, by contrast, has expanded in a number of phases. Both Chinese systems in the study, Changshu and Zhongshan, have also seen large expansions. The largest relative expansion of all however is Taipei City, which has increased in size by ten times, in less than four years. Along the way, it created some extremely large docking stations, many surrounding the Taipei 101 skyscraper in the city's business district, before expanding again into the wider city, into areas which do not have such a high daytime population density, resulting in the average docking station size decreasing but still remaining the largest of all the studied systems, as can be seen in Figure 4.

Other cities that have seen major expansions relative to their previous size include Mexico City, a notably compact and high-density system (O'Brien et al 2013) that has spread to nearby suburbs, and Rio de Janeiro which similarly has seen deployments of docking stations into new areas. Washington DC has expanded relatively evenly each year, while Dublin's small and very popular system (O'Brien et al 2013) recently saw a long awaited expansion. San Antonio, a small system in the USA, has expanded from its city centre origin, along a corridor of parkland to the north and south, tripling in size and reflecting its popularity as a leisure mode of travel here.

Few systems have shown signs of stagnation or decrease. Large and established systems (Barcelona, Lyon, Rennes) have remained constant, while Miami Beach, a system which is heavily tourist-focused, has seen a decline since 2012, dropping below 100 operating docking stations in the last year. One system observed here – Ottawa/Gatineau – has not yet restarted in 2014 due to its operator filing for bankruptcy protection – such a fate has also happened to some smaller systems (e.g. Oxford) not included in the study.

The biannual counting period mitigates the effects of winter closures practiced by many cold-climate systems, particularly in North America, however it means that some kinds of expansions are not shown. For example, Chicago's system launched in mid-2013 in several planned phases, each spaced only a few weeks apart. By October, it had already quintupled in size. The effect of the particularly late post-winter reopening in Montreal is seen in Figure 4, where the observed maximum bike/dock ratio is always lower than in both the preceding and forthcoming October, because the operator activates all the docks during April, but has not finished in placing the full number of bicycles in the system by the end of the month.

Figure 4 shows a particularly interesting trend for Milan. This compact system, concentrated in the city's historical core, has been expanded steadily over the period of study, but rather than increasing the system's overall footprint, both the size and density of docking stations have increased (and accordingly the number of bicycles per docking station) to a point where it now has the fourth highest numbers of bicycles per docking station, behind Taipei City and the much larger systems of New York and Paris. One characteristic seen in the latter three is very high usage peaks, particularly during weekday commute periods. Having very large numbers of bicycles at certain docking stations likely helps sate the asymmetric and time-skewed demands of commuters.

6. Conclusion

The numbers of bicycle sharing systems are rising quickly, and some existing systems are also adapting. The analysis shows various different policies carried out by cities in meeting this demand – by expanding, intensifying both docking stations and bicycles numbers. In other cases, reductions are being seen. With many systems evolving rapidly, and in different ways, ongoing close attention on the dynamics and changes of the bikesharing industry will continue to be revealing.

Acknowledgements

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Appendix 1. Table of measurements

			Maximum Observed Available Bicycles								Maximum Observed Docking Stations							
City	Country	Continent	Oct-2010	Apr-2011	Oct-2011	Apr-2012	Oct-2012	Apr-2013	Oct-2013	Apr-2014	Oct-2010	Apr-2011	Oct-2011	Apr-2012	Oct-2012	Apr-2013	Oct-2013	Apr-2014
Barcelona	Spain	Europe	5094	4583		4731	3815	4406	4664	5115	398	413		418	424	424	424	424
Bordeaux	France	Europe	1332	1325	1298	1305	1326	1209	1287	1203	134	137	137	136	136	137	139	140
Boston	USA	North America			549	567	932	902	1080	1077			60	60	104	107	130	133
Boulder	USA	North America			108	104	126	135	131	133			15	15	19	23	23	22
Brisbane	Australia	Oceania				1617	1869	1816	1930	1832				129	151	151	151	151
Brussels	Belgium	Europe	1753		2118	2324	3377	3788	3645	3742	180		178	202	295	323	308	331
Calais	France	Europe				95	215	221	208	233				20	34	35	37	39
Changshu	China	Asia			1590	1795	5924						155	155	357			369[3]
Changwon	South Korea	Asia					2625	2575	2570						235	235	235	236[4]
Chattanooga	USA	North America					225	252	254	279					35	33	32	33
Daejeon	South Korea	Asia					632	693	905	960					104	114	145	146
Denver	USA	North America	357	374	385	368	421	462	584	578	49	50	52	51	53	67	80	82
Dublin	Ireland	Europe	403	485	490	481	481	454	579	704	40	44	44	44	44	44	45	71
Girona	Spain	Europe	130	175	139	135	135	127	127	127	10	10	10	12	12	12	12	12
Kanazawa	Japan	Asia					139	138	144	141					20	20	20	20
Lille	France	Europe			905	1221	1768	1979	2031	2064			86	124	192	198	211	213
London	UK	Europe	4319	4398	5138	7044	6830	7664	7484	9501[5]	348	399	410	563	568	564	573	739
Lyon	France	Europe	3063			3472	3304	3378	3250	3224	342			345	345	345	346	346
Melbourne	Australia	Oceania	404	411	550	543	553	547	551	545	50	50	51	51	50	51	51	51
Mexico City	Mexico	Latin America	1043	1164	1117	1145	2039	3364	3396	3359	86	90	90	90	163	267	268	273
Miami Beach	USA	North America		444	615	522	644	648	554	601		84	92	112	113	101	96	98
Milan	Italy	Europe	1196	1157	1426	1669	1716	2506	2897	2777	102	107	120	128	147	182	187	193
Minneapolis	USA	North America	594	588	1018	932	1277	1209	1271	1446	65	73	116	116	145	146	170	170
Montreal	Canada	North America	4437	3936	4350	3854	4549	3829	4164	3594	407	405	405	411	406	409	437	454
New York	USA	North America							4621	5233							333	331
Nice	France	Europe				1387	1382	1477	1315	1379				174	172	170	169	169
Ottawa	Canada	North America			98	197	251	240	244				10	21	25	23	23	0[6]
Paris	France	Europe	17996			18142	17202	18847	15640	17902	1203			1202	1208	1227	1214	1207
Recife	Brazil	Latin America							261	426							41	80
Rennes	France	Europe	821	836	835	844	712	790	752	808	83	83	83	83	83	83	83	82
Rio de Janeiro	Brazil	Latin America	58	27		357	321	358	293	512	19	19		56	61	59	57	77
San Antonio	USA	North America		109	174	201	240	293	406	395		14	20	23	30	35	51	52
São Paulo	Brazil	Latin America						592	661	740						96	127	139
Saragossa	Spain	Europe	887	1020	966	1223	1070	1211	1178	1231	100	107	129	128	128	129	130	130
Seoul	South Korea	Asia			308		307	313	335	306			43		44	44	44	44
Seville	Spain	Europe	1941						2139	2173	244						260	259
Taipei City	Taiwan	Asia			377	311	1750		2428	3116			11	11	42		115	166
Tel Aviv	Israel	Middle East			975	1118	1040	1268	1273	1305			125	147	151	170	171	181
Toronto	Canada	North America			817	815	855	796	753	741			80	80	80	80	81	80
Toyama	Japan	Asia	139						132	158	15						15	17
Valencia	Spain	Europe	1039			2471	2431	2483	2398	2360	175			272	280	276	276	276
Vannes	France	Europe				96	154	154	154	152				25	25	25	25	25
Vienna	Austria	Europe	754	843	940	1048	1119	1181	1333	1360	73	79	84	94	100	102	114	116
Washington DC	USA	North America	724	907	867	1318	1609	1852	2121	2596	113	119	117	164	191	218	288	318
Yokohama	Japan	Asia			151	180	210	193	186	259			22	24	28	32	34	34
Zhongshan	China	Asia					2553	3487	4495	5110					201	286	395	474

Missing values indicate where data was not being collected at this time.

3 Manual observation on operator website.
4 Manual observation on operator website.
5 9901 observed on 1 May 2014.
6 System failed to reopen in April 2014 following operator financial issues.