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**ABSTRACT**  The rapid expansion of bike-share systems worldwide has been praised as a sign of the environmental movement, with positive consequences for transportation, the economy, and health in urban areas. But is it really possible that politicians, information-technology companies, and global players such as banks and advertising firms have suddenly joined the ranks of those advocating bicycle use for the sake of the environment and a better quality of life in cities? Bike-share systems, like any other artifact, are a technological assemblage formed by technical, cultural, economic, and social factors and actors. When this assemblage stabilizes and is socially accepted, debate cools down and some unresolved features are put aside. We argue that disassembly of the bike-share system, highlighting the use of electronic keys, credit cards, and the strategic location of docks in upmarket urban areas, may enable us to unveil some of its features and reveal a more complex sociotechnical assemblage.

**KEYWORDS**  bike-sharing; technological assemblage; surveillance; advertising

**Introducing the Phenomenon**

Bike-sharing systems have been implemented around the world at a fast pace over the last ten years. According to Peter Midgley (2014), from less than 100 bicycles in 2002, by 2013 the bike-sharing fleet had exceeded 600,000—with the largest programs in Asia and Pacific rather than in European cities, which first started implementing bike-sharing systems (BSSs) (Larsen, 2013). Similarly, an increasing number of academic papers have been published on different aspects of bike-sharing systems, from quantitative analysis and modeling to more qualitative discussions of user behavior (Fishman et al., 2013).

What lies behind the bike-sharing system (BSS) phenomenon? The phenomenon of BSSs is certainly to be welcomed after decades of urban transportation involving the expansion of road infrastructures aimed at accommodation of more, faster, and bigger private vehicles. The vertiginous increase in BSSs as a response to the growing awareness of the harmful effects of private motorization can certainly be said to be part of the reason behind this phenomenon. And we...
would like to believe that BSSs are simply part of a movement to promote active modes—such as bicycles and pedestrian infrastructures—and public transportation around the world. This is partially true, for the implementation of Bus Rapid Transit has also gained more advocates worldwide over the same period (Deng and Nelson, 2011). Still, the fast pace of BSS expansion deserves alternative analyses.

The hypothesis of this essay is that explanation of a quite global phenomenon must be tied to other parallel global factors and values, and consequently that bike-sharing systems are driven more by these global values than by ordinary transportation analysis. Indeed, values such as the promotion of a healthier lifestyle and concerns about the impact of motor transport on the environment have been responsible for the “renaissance” of bicycle culture (Pucher et al., 2011), and increased use has also influenced the bicycle industry (Rosen, 2002). In the political arena, politicians around the world have embraced and promoted BSSs as a sign of their environmentally friendly stance (Medeiros and Duarte, 2013). In this paper, we focus on the technological assemblage that has fostered the vertiginous increase in the implementation of BSSs. We propose to do it through the conceptual lenses of the social construction of technologies.

A BSS, like any other artifact, is a technological assemblage of different technical, scientific, social, economic, and political values. As Bijker (1997) has shown in the case of the bicycle as a vehicle, technologies are socially constructed, meaning that the artifact is the material element of a vast network of actors, purposes, and other possible technological alternatives. All but one of the alternatives are abandoned, not necessarily because the chosen alternative is remarkably better than the others, but because it is best suited to a particular sociotechnical context. The adoption and proliferation of the best-suited artifact depends on its technological stabilization. Once the relationships between the different social, economic, political, scientific, and technological elements stabilize, all other alternatives tend to disappear and any remaining discrepancies among these elements tend to be smoothed over. At this point the enthusiasm involved in the sociotechnical construction of the artifact cools down and a sort of technological consensus is achieved. The artifact seems to be complete, to be working as it should. This process is called “closure” (Pinch and Bijker, 1984; Hard, 1994) or “obduracy” (Hammels, 2005). The technology is then socially accepted and obdurate, and may be replicated infinitely, while the process that led to its formation is seldom remembered, let alone questioned.

In this essay, we propose that the breathtaking expansion of BSSs can be understood through the conceptual lenses of the social construction of the BSS as a technological assemblage, and contribute to analysis-based transportation theories and methods. And as the adoption of BSSs relies on technological obduracy, we propose to disassemble BSSs methodologically, starting by identifying which components constitute the standard BSS, and what the possible roles of each component are in making BSSs such a phenomenon.

Bike-Sharing Systems: Opening the Black Box

The growth of BSS is part of what has been called the “bike renaissance.” In a broad technological framework, the bicycle renaissance includes the expansion of bicycle infrastructure (bike paths, bike lanes, bike parking), the bicycle incor-
porated as part of multimodal networks (bike racks on buses, bike-friendly subway systems), new traffic regulations (mandatory safety bars for lorries, and helmet use), and a bike-friendly political agenda. One of the challenges of socio-technical analysis is to draw the boundaries of the sociotechnical system. In this paper, we do so by isolating the components which differentiate BSSs from other bicycle programs—for instance, cities are fostering the use of bicycles with more infrastructure, political support, and better regulations, without implementing BSSs. Finally, we have also privileged components that gather and utilize the users’ personal data, because our argument is that the collection and analysis of these data have a special interest for private firms in sponsoring such bike-sharing systems.

BSSs are quite similar everywhere. In terms of physical apparatus, there is the bicycle, which is specially designed, normally heavier (and more stable) than ordinary urban bicycles, with a minimum of detachable parts; and the docks, where the bicycles are attached when not in use. Although there are a few systems in which the user can park the bicycle anywhere and lock and unlock it using a cell phone (Shaheen et al., 2014), the basic infrastructure of most systems involves docking stations at specific locations.

Regardless of the docking systems, the most common BSSs have two types of user: the occasional user and the regular user, who becomes a member (Shaheen et al., 2014). With a very few exceptions, payment must be made using a credit card, through the Internet, or at the docking station. Clearly, the possibility of processing credit-card payments at the docking station means that it is also connected to the Internet. For this same reason, the BSS operator knows how many bicycles are parked at which station. It allows real-time, origin-destination surveys and data visualization, and also allows the user to plan his/her trip with mobile-device apps, knowing at which dock bicycles are available and which docks have available spots for bicycle return. Finally, docks usually have a display panel, which typically has a map of the neighboring docks on one side and an advertising billboard on the other.

As we have noted, the rapid expansion of BSSs around the world, reaching more cities in Asia and the Americas in recent years (Shaheen et al., 2010; Larsen, 2013) relies on these common characteristics. It is not simply a matter of technological reproducibility—although there are a few global players in the BSS business, such as Alta, JC Decaux, etc. Our argument is that beyond the material artifact lie other values that make this technological construct stable, obdurate, and, therefore, unquestionably reproducible. To emphasize this point, we would like to highlight three characteristics of most BSSs: the use of electronic keys, the use of credit cards, and the location of the docks.

**E-Keys and Surveillance**

BSS members unlock their bicycles using electronic IDs, which can be a card, a key, or cellphone code. When returning the bicycle, the loop is closed: the system gathers data about who took which bicycle where, how long it took to be returned, and where it was returned. The use of electronic ID technologies in transportation is quite usual, ranging from cards used in public transportation to the electronic keys or cell phone codes used to unlock bicycles and cars in sharing programs. Public transportation cards are normally anonymous, while both car- and bike-
sharing e-keys are personalized. This means that in addition to the possible origin-destination patterns generated with these data, which can be useful for traffic and transit planning, there is another important issue: BSS operators not only know how many bicycles went from point X to point Y at what time—which is management information—but they also know exactly who made each trip. BSS advocates have recently been pointing out a tendency towards incorporation of more accurate tracking technologies such as GPS (DeMaio, 2009), and O’Brien et al. (2014) showing how data mining can help global analysis of BSSs.

Nevertheless, although this might seem to be simply a management issue and it is probably the best technology available for BSS operation on a large scale, it still raises the question of the pervasive surveillance of society. Analyzing Vélib, the Parisian BSS, Dominique Boullier and Maxime Crépel state that “Biking is no longer simply using a bike, it means being tracked down for each segment of one’s trip (the basic fee limits the use to 30 minutes) and accepting it” (2014: 50). As David Lyon (2009: 451) points out, “it is not merely that some kinds of surveillance seem invasive or intrusive, but rather that social relations and social power are organized in part through surveillance strategies.” Jisuk Woo (2006) expresses a concern that is quite common among surveillance scholars, which is that people are voluntarily giving up their privacy in exchange for specific services, in a transaction where the user does not even know which personal data is collected or even what cross analyses are possible within extensive databases (see also Perusco and Michael, 2007). In the surveillance society, personal data becomes a valuable asset for public and private companies.

Credit Cards

Both one-off users and members alike require a credit card to use a BSS. The requirement of using a credit card has two purposes: first, the operator is guaranteed that if the bicycle is not returned, a set fee will be charged to the user’s credit card; and second it allows the operator to ensure payment of usage charges. These two reasons are simple and effective from the management point of view, and by reducing potential losses caused by bicycle theft and unpaid usage charges, they may allow operators to charge relatively low rates on entering the business.

Similar to what happens with e-keys, credit card use generates a database of personal information. Whereas people are generally quite cautious and even negative regarding explicit surveillance, such as video cameras, they seem much less concerned about or unaware of more pervasive surveillance technologies such as credit cards (Lyon, 2002); however, each credit card transaction triggers a powerful apparatus of data collection and analysis. Two issues should be raised about the combination of these two traceable technologies.

The first is simply the combined analysis of e-key and credit card data. Potentially, an agreement between credit card companies and BSSs operators may link two critical market data: the credit history as well as the purchase history (including amounts, items bought, and most used stores) of a user who travels by bicycle at particular times and in particular regions. Such information is valuable for marketing purposes.

Here we would like to focus on the second issue, though: what about those who do not have a credit card? “The 2000s were the big decade for plastic, as credit and debit cards come to dominate the way we pay” (UK Cards, n/d: 2).
From 2003 to 2012 the United States saw a 4.5 percent annual increase in noncash payments (FED, 2013), mostly with debit and credit cards. Part of the population has no credit cards, however—mainly low-income families. For example, 53 percent of US students from high-income families use credit cards, against 31 percent from medium-income families, and 29 percent among low-income families (Ray and Ghahremani, 2014). Arguing that credit cards are the “building blocks of a consumer’s ability to access credit in the future,” Ethan Cohen-Cole (2011: 702) assessed the spatial correlation between race and credit files, and discovered that “black areas will be poorer and have lower credit quality on average” (2011: 700). This finding reinforces the known correlation between race and social inequality in the United States. But how might this socioeconomic analysis relate to BSSs? Figures 1 to 3 show the coverage of the BSSs in Boston, London, and New York, paired with median income.

Docks are mainly located in central areas, densely populated neighborhoods, and close to subway stations, which is to be expected and a good sign from the transportation point of view (Toole Design Group, 2012). In the operational standpoint it makes sense: a system that has close station spacing, and in neighborhoods more densely populated and, even better, with occasional users who pay per trip, is more desirable. However, it is still notable that low-income, medium-density areas are more poorly served by BSS provision in comparison with other equally medium-density neighborhoods.

In New York, the first phase of the Citibike was concentrated in north Brooklyn and south-of-Central Park Manhattan, mostly wealthy areas, with the second phase launched in late 2014 after several struggles between the operator and the city. BSS social inequalities also occurred in London, where women and poor people are underrepresented among users (Ogilvie and Goodman, 2012; Permuter, 2014). The same applies to Toronto, Chicago, and Mexico City, where BSS members are disproportionally concentrated in high-income households (Grabar, 2013; Jaffe, 2014).

We are not implying that the location strategy for BSS docks is a matter of deliberate social prejudice, but simply that there is a correlation between low-income families and the use of credit cards, and that without credit cards the BSS does not work. In short, the low-income population does not fit the BSS technological construct. These two issues highlight a statement that is quite obvious in urban studies: location matters. It reveals those who have access to a service, and those who don’t. Compared to massive direct and indirect investments in private transportation, BSS is far more inclusive. Nevertheless, a perfect match of BSS with a more socially inclusive mode of transportation is not a given.

Location, Location, Location: BSSs and the Advertising Market

Arguably, implementing BSSs is much cheaper than building and maintaining other urban transportation modes. Besides, BSSs use a fraction of a major existing road infrastructure. Still, some cities have seen the BSS expansion delayed or stalled because operators claim the system is expensive, and even in major cities the main sponsors are struggling to fulfill expansion contracts (in New York) or are backing out, such as in London (Topham, 2013), where each bicycle costs £1400 a year—“enough to buy each of the scheme’s 38,000 registered
users a £290 bike” (O’Sullivan, 2013). Bixi, the Montreal-based BSS operator, which supplies systems for several other cities, including San Francisco, London, and Boston, filed for bankruptcy in early 2014 (Fried, 2014).

Figure 1: (a and b): Bike-share docking stations and median income—Boston
Figure 2: (a and b): Bike-share docking stations and median income—London
Figure 3: (a and b): Bike-share docking stations and median income—New York
And this is where the importance of location comes in. It is quite obvious from a transportation standpoint that the location of docking stations is a key feature in the overall performance of a BSS (DeMaio, 2009; O’Brien et al., 2014). Research papers and technical reports (Toole Design Group, 2012; ITDP, 2013) stress the necessary multi-criteria analysis used to locate BSS docks, including the mix of uses, trip distances, destinations, tourist activity, topography, and population density. Yet the location does not always relate merely to a transportation analysis—as we have already seen, with BSSs providing worse service to relatively dense neighborhoods than to richer areas that are less densely populated.

Here we can argue that the location of BSS docks may be related to other spatial factors. Rio de Janeiro is the second-most-populous city in Brazil, with socioeconomic disparities represented by the favelas and an impoverished periphery. But the city is also the main tourist destination in South America, accommodated important FIFA World Cup matches in 2014, and will host the Summer Olympics in 2016. A few years ago the city implemented a BSS. Most docks are located along the shoreline and in neighborhoods visited by tourists and populated by high- and medium-income residents. We have discussed this same pattern earlier, but it is worth mentioning another characteristic: Rio de Janeiro has very restrictive outdoor advertising regulations which forbid advertising panels along the shoreline and near the main tourist attractions. The BSS in Rio is funded by Itaú, a major bank, and all bicycles bear the bank logo and color. This is arguably a good strategy for promoting the bank, associating it with an environmentally friendly and socially accepted mode of transportation, in an area with restrictive advertising regulations.

The same happens elsewhere. In London the main sponsor was initially Barclays, and is now Santander; in New York, Citibank; in Barcelona, Vodafone; in Toyama, Unilever. Advertising firms have become major global players in the bike-sharing business, and the contract between JCDecaux and the city of Paris is a landmark in this field (López-Pumarejo, 2011). JCDecaux paid the start-up cost of $115 million to launch the Paris BSS and maintains the operation of the system in exchange for exclusive rights to commercial exploitation of city-owned billboards (Midgley, 2009). In Barcelona, ClearChannel reached a similar contract (See Table 1).

Other BSSs have neither a single sponsor nor are operated by an advertising company; but stickers on bicycles and billboards at BSS docks still provide an

<table>
<thead>
<tr>
<th>City</th>
<th>Active docks (Aug. 11, 2015)</th>
<th>Capital cost per bicycle</th>
<th>Main Sponsor / Operator</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paris</td>
<td>37,912</td>
<td>–</td>
<td>JCDecaux</td>
<td>Advertising</td>
</tr>
<tr>
<td>London</td>
<td>18,824</td>
<td>$4,000</td>
<td>Santander</td>
<td>Bank</td>
</tr>
<tr>
<td>Barcelona</td>
<td>10,415</td>
<td>$3,150</td>
<td>ClearChannel / Vodafone</td>
<td>Advertising / Telecom</td>
</tr>
<tr>
<td>New York</td>
<td>11,191</td>
<td>$4,750</td>
<td>Citibank</td>
<td>Bank</td>
</tr>
<tr>
<td>Montreal</td>
<td>9,537</td>
<td>$4,000</td>
<td>Télus</td>
<td>Telecom</td>
</tr>
<tr>
<td>Mexico City</td>
<td>11,803</td>
<td>$3,400</td>
<td>ClearChannel</td>
<td>Advertising</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>3,222</td>
<td>$1,810</td>
<td>Itaú</td>
<td>Bank</td>
</tr>
</tbody>
</table>

Source: http://bikes.oobrien.com; ITDP (2013); BSS websites
important source of revenue—considering that more than 95 percent of all trips in
Boston and New York last less than 30 minutes, the system costs are not covered
by membership alone. And as advertising is very important for business, dock
locations and cycle-use patterns become important market assets.

Advertising is also an important source of resources to other public modes—
and this is not a problem, since it is part of the business model. However, when
one sees flagship cities such as London, New York, and Barcelona delaying or stal-
ling their BSS expansion to more peripheral and/or poor neighborhoods, we must
consider the reasons. By locating BSS docks in more upmarket neighborhoods,
BSS operators are not only targeting richer (credit-card holders serve as a
proxy) potential users, but also richer consumers who do not need to ride bicycles,
but who welcome the BSS as a sign of an environmentally friendly and modern
lifestyle. And consequently associate BSSs with the firms that sponsor them.

Conclusion

The vertiginous growth in bike-sharing systems implemented worldwide over the
past 15 years is worth discussing. The environmental, economic, and health
benefits to city dwellers, even those not using bicycles, are commonly taken as
the reasons for the adoption of BSSs and other measures to boost the use of
bicycles. Though praiseworthy, we have argued in this essay that this phenom-
enon reveals characteristics and implications for cities beyond those shown by
usual transportation analysis. We proposed analysis of the BSS as a technological
construct using concepts from the social construction of technologies, rather than
through the lenses of transportation theories.

The global adoption of any technology relies on a certain degree (actually, a
huge degree) of technological obduracy, a point in the sociotechnical process at
which a clear consensus is reached, allowing the artifact to be reproduced infi-
nitely. An artifact, however, is not simply its materiality, and technological obdu-
racy is not merely a matter of having well-designed pieces arranged correctly. It
also involves the stabilization of social and economic values.

In this essay we have tried to disassemble the BSS to show some components
of this technological assemblage that could reveal why this system has been
adopted so widely and efficiently worldwide, supported in not a few cases by
major private companies. We have focused on three components: the use of e-
keys to lock and unlock bicycles, the use of credit cards in all BSS transactions,
and the location of BSS docks and its relation with socioeconomic characteristics
and outdoor advertising regulations and firms in a few metropolises.

We have used this analysis to try to demonstrate that neither the potential
environmental, economic, and health benefits of bicycle usage nor transportation
analysis can explain alone the rapid growth in global adoption of BSSs. We argue
that a BSS might be part of a broader technological assemblage that involves
extensive gathering of personal data, which can be mapped in real time and
matched with other socioeconomic and urban features and marketing strategies
that take advantage of the powerful environmentally friendly image associated
with bicycles, combined with increasing restrictions or high prices for outdoor
media in big cities. Within this conceptual framework, the BSS is not a final arti-
fact, but actually a convenient medium for catalyzing broader technological
assemblages.
Notes
3. For a map with Chicago BSS stations and income, see http://geocommons.com/maps/266797
4. Follow the running story about the struggles to expand NY BSS at http://www.streetsblog.org/category/issues-campaigns/bike-sharing/

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