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CAPITAL BIKESHARE: ANALYZING BIKE RENTAL DEMAND

Abby Xiong wrote this case under the supervision of Joe Naoum-Sawaya solely to provide material for class discussion. The authors do not intend to illustrate either effective or ineffective handling of a managerial situation. The authors may have disguised certain names and other identifying information to protect confidentiality.

In November 2018, Aaron Goldbeck was reviewing his expansion plan of adding 40 new bike rental stations to the current Capital Bikeshare network across Washington, DC. Goldbeck was a bicycle program specialist working in the Planning and Sustainability Division at the Washington, DC, District Department of Transportation (DDOT). Goldbeck had noticed that bike-sharing programs were frequently in the news.

On April 9, 2018, Uber Technologies Inc. announced its acquisition of Jump, a dockless and electric bike-sharing operator that began offering services in 10 cities across the United States after piloting a scheme of dockless electric bicycles in hilly San Francisco. Three months later, Lyft Inc. acquired bike-sharing company Motivate, which was responsible for operating a number of popular bike-sharing systems, such as Citi Bike in New York City and Ford GoBike in San Francisco.

In the current era, every city strove for an eco-friendly and sustainable system for sharing vehicles. The ever-growing industry of ride-sharing companies saw bike sharing as a natural extension of their easy urban mobility approach toward developing a smart city.[1]

Capital Bikeshare, a regional bike-sharing program in Washington that was owned by the DDOT and operated by Motivate, was also capitalizing on the trend of bike sharing, and its avid riders were enjoying the benefits of renting and returning a bike at any of the program's 8,635 docks.[2] Every minute, the system generated a large volume of trip data that was available for analysis. Goldbeck and his team had heard the following questions since launching in 2010: Who were the riders that used Capital Bikeshare? When did they ride? What days of the week were most rides taken on? What factors affected riding behaviours?

With the emergence of smart analytics, what useful ridership insights could Goldbeck extract from Capital Bikeshare's datasets? How could this information best help Goldbeck to prepare a future expansion plan?

[1] A smart city was an urban area where data and information were collected using information and communications technologies and then used to optimize the management of resources, services, and operations across the city.
[2] "Press Kit," Capital Bikeshare, accessed October 10, 2018, https://www.capitalbikeshare.com/press-kit.

CAPITAL BIKESHARE PROGRAM

Capital Bikeshare was a station-based bike-sharing operator that provided an expansive, multi-jurisdictional transportation system to (a) Washington, DC; (b) the neighbouring counties of Arlington, Virginia; Prince George, Maryland; Fairfax, Virginia; and Montgomery, Maryland; and (c) the city of Alexandria, Virginia. It was the first public–private partnership bike-sharing system in the United States and had been the largest until May 2013, when New York's Citi Bike launched. The Capital Bikeshare system was owned by the participating jurisdictions and was currently operated by Motivate, a New York-based company that operated several other bike-sharing systems in different cities.

To achieve its mission "to transform our community by providing a high quality, convenient and affordable bicycle transit system that will connect people to more places where they live, work and play in the region," Capital Bikeshare offered five distinct membership options, tailoring to both registered and casual riders. People could join for a single trip, a day, three days, a month, or a year. All memberships had an initial fixed rate, plus the extra amount that was paid depending on the time of use—though the first 30 minutes of each trip was free. Single-trip, 24-hour, and three-day membership customers received a five-digit key that they could insert into any bike dock with an available bike, at any station. Monthly or annual membership customers received a card that they could use to rent bikes. By 2018, Capital Bikeshare had more than 4,300 bicycles at a total of 500 stations and had provided more than 20 million fun and affordable rides to metropolitan DC dwellers.[3]

BIKE-SHARING BOOMS

Overview

A bike-sharing system was "a self-service, short-term, one-way-capable bike rental" offered "in public spaces, for several target groups, with network characteristics."[4] By integrating information and communication technology into everyday life, bike-sharing programs had received increasing attention in recent years as a popular and strong green-minded alternative to automotive-centric transport services. The benefits of a bike-sharing program often centred on the goals of promoting cycling, reducing congestion, improving air quality, and offering residents an active mobility option. The bike-sharing system, following an asset-light approach and allowing users to share mobility offerings, was available in more than 70 countries. By 2017, with nearly 1,600 bike-sharing systems in operation worldwide, the number of shared bicycles hit an estimated 18.2 million.[5] The overall market reached €6 billion[6] in 2018 and was expected to grow continuously by 20 per cent, making the bike-sharing model a fast-growing permanent feature of the urban landscape.[7]

[3] "Experience Metro DC on Two Wheels," Capital Bikeshare, accessed October 10, 2018, https://www.capitalbikeshare.com/how-it-works.
[4] Avgi Vassi and Thanos Vlastos, "Bike Sharing Systems: Effectiveness, Impact and Assessment," in *European Transport Conference 2014* (London, UK: Association for European Transport, 2014), 1–12.
[5] Prachi Bhardwaj and Shayanne Gal, "The Number of Bike-Sharing Programs Worldwide Has Doubled since 2014 — and the Number of Public Bikes Has Increased Almost 20-Fold," Business Insider, July 3, 2018, accessed October 10, 2018, https://www.businessinsider.com/bike-sharing-programs-doubled-since-2014-public-bikes-charts-2018-7.
[6] € = EUR = euro; US$1 = € 0.8774 on November 1, 2018.
[7] Roland Berger, *Bike Sharing 5.0: Market Insights and Outlook*, August 2018, accessed October 2, 2018, https://www.rolandberger.com/publications/publication_pdf/roland_berger_study_bike_sharing_5_0.pdf.

Evolution of Bike-Sharing Programs

Originally a concept from the revolutionary 1960s, bike sharing was slow to grow over the years. However, better approaches to bike tracking as well as improved information technologies had given birth to the rapid expansion of bike-sharing programs throughout the globe in recent decades.

The past 50 years had seen four generations of bike-sharing systems. The first generation started in the summer of 1965, in Amsterdam, with *Witte Fietsen* (White Bikes). Ordinary bikes painted white were provided free of charge for public use as a political statement of concern for pollution and against the growing number of cars in the city. Even though the program collapsed within days due to heavy bike theft and vandalism, the White Bikes were the world's first demonstration of a bike-sharing program, providing increased mobility to Amsterdam dwellers.[8]

The second generation, led by Copenhagen's *Bycyklen* (City Bikes), began to emerge in Europe through public–private partnerships in the late twentieth century. Aside from significant functional improvement in bikes specifically designed for intense utilitarian use, the development of software for tracking and managing bicycles laid the foundation for the locking system at specific stations. City Bikes allowed users to pick up and return bicycles at different stations throughout the central city via a coin-deposit system, which answered the need to deter theft and incentivized bicycle return.

The invention of individualized magnetic stripe cards in 1996 put an end to the bike theft problem. In contrast with the first two generations, the third generation used a smart card to produce real-time information and assist in rebalancing the bikes between different stations as part of a complete technology-enhanced operating plan. The bike-sharing system started to adopt smart-card technology in 1998, and when the Vélo'v system in Lyon, France, opened in 2001, it soon became the prototype for the third generation of the system. Throughout the following 10 years, the demand-responsive and multimodal "smart" dock system took hold in multiple locations across the globe, with many stations installed at strategic locations to answer riders' natural demand for "the last mile" problem in their commutes and to grow a top-of-mind green transportation method in dense urban areas.

In 2015, a new free-floating bike-sharing model started to become popular in Asia, particularly in China. The rapid development of bike-sharing schemes was enabled by the advent of new technologies such as mobile payments, the Internet of things, and bike locking and tracking systems, which allowed dockless bike businesses to thrive.[9]

Motivation and Evaluation for Bike-Sharing Programs

From the perspective of the individual, bike sharing attracted riders through its convenience and practicality. When leveraging other modes of transportation, bike sharing could provide a fundamental shift in the way people moved around and made decisions about transportation. It filled the critical gap between the bus or train station and the final destination and improved public mobility by extending fixed-route transit services, thereby increasing accessibility for dwellers and visitors. Bike sharing also offered an active transport choice, providing easy access to the physical and mental health benefits of bicycling while helping riders to fulfill their personal mission of embracing an environmentally friendly and green lifestyle.

[8] Tucker Gaegauf, A2B Bikeshare, *A Comparative Guide to the Different Technologies Offered by Bikesharing Vendors*, June 2014, accessed March 9, 2021, http://mobility-workspace.eu/wp-content/uploads/Bikeshare_Technology_White_Paper.pdf.
[9] "The Global Bike-Share Boom: Dockless Models Look to Solve Urban Commutes & Transit Access," CB Insights, March 22, 2018, accessed July 15, 2020, https://www.cbinsights.com/research/bike-sharing-boom/.

From a municipal perspective, bike sharing could improve a city's image and branding as a green or innovative "smart" city and held the potential to stimulate general investments in local industries through continuous demand for hardware, software, and the provision of operations. From an investment perspective, bike-sharing systems offered many key advantages over other transportation systems, with the capital cost in establishing a viable network comparatively lower for bike-sharing systems. Furthermore, the relatively short timeline to begin operating the system meant that the benefits to the public were attained quicker than was the case with most transportation projects.[10] In the planning stage, there were five key elements to consider when building a cost-effective, high-performance bike-sharing system.[11] The stations needed adequate spacing to offer maximal coverage as well as convenient walking distances to riders. It was common to have 10–16 bike stations in every square kilometre, with stations spaced 300 metres apart. To ensure reasonable demand for the system, typical bike-sharing programs covered areas of at least 10 square kilometres. The number of bikes that were deployed depended largely on the density of the area. Typically, 10–30 bikes were allocated for every 1,000 residents. Areas with a high influx of commuters received an even higher number of bikes to ensure capacity during peak demand hours. Bikes needed to be durable, attractive, and practical to limit repair costs and encourage adoption. The bikes were also designed to discourage theft. Finally, technology needed to permit easy bike checkout and return processes. The real-time availability of bikes, mobile payment, and automated locking were essential elements for a desirable bike-sharing system.

Bike-sharing operators and cities presented bike-sharing programs as a viable means of transportation rather than as an occasional fun activity. Paul Stratta, director of the Platform for European Bicycle Sharing & Systems, a European forum for intra-industry collaboration that guided cities in planning and operating bike-sharing programs, stated that

> for bike share schemes to be seen as a real public transport solution and a smart answer to urban mobility, they need to work as good or better than existing public transport services. People go to bus and railway stations expecting the services to be there, and for them to operate on time. It should be the same with bike share schemes.[12]

While the bike-sharing idea was gradually advocated by the general public across the globe, and with high expectations, the need for continuous strategic and operational improvements required special attention to fulfill riders' dynamic demands and to respond agilely to external variabilities.

BIG DATA BEHIND BIKE SHARING

As bike-sharing models entered into the new era of "smart mobility," which was often considered a city's virtual sensor network, a key trend of bike-sharing culture was the open sharing of data about ridership trends, allowing the public to analyze trip patterns and build various predictive algorithms to help maximize utilization of the bike fleet. The data generated by these bike-sharing programs was attractive for studying mobility in a city, as customer data, duration of travel, departure location, arrival location, time elapsed, and other trip features were systematically collected, exchanged with partners, and used to improve the customer experience. Smart cities and smart companies alike had already seen the additional potential value of bike-sharing systems to provide sanitized and enriched movement data for generating ancillary commercial revenues.

[10] Aimee Gauthier et al., *The Bike-Share Planning Guide* (New York, NY: Institute for Transportation & Development Policy, 2014), accessed October 2, 2018, https://3gozaa3xxbpb499ejp30lxc8-wpengine.netdna-ssl.com/wp-content/uploads/2014/07/ITDP-Bike-Share-Planning-Guide-1.pdf.
[11] Ibid.
[12] "London Comes Out Top for Usability in Major Bike-Share Schemes," Intelligent Transport, November 9, 2017, accessed July 15, 2020, https://www.intelligenttransport.com/transport-news/29911/london-top-bike-share-usability/https://www.intelligenttransport.com/transport-news/29911/london-top-bike-share-usability/.

Goldbeck knew that Capital Bikeshare also kept a complete history of its ride trips, and he was particularly interested to see how data analysis could provide some insights about Capital Bikeshare's bike-sharing users as well as suggest some improvements in Capital Bikeshare's operation model. Hourly rental demands on the Capital Bikeshare system were collected for the period between October 1, 2016, and September 30, 2018 (see Exhibits 1 and 2).[13]

THE DEMAND FOR BIKES

Over the years, Capital Bikeshare experienced a steady rise in bike rentals. The bike-sharing program tried to keep up with growing demand from its enthusiastic fans through expanding its coverage area and adding new station locations. It also wanted to incorporate a strategic evaluation into its current operation system to optimize its top line by raising system efficiency and recruiting more people to join this green transportation alternative. One of the challenging problems that Capital Bikeshare now faced was the difficulty of meeting the fluctuating demand for bike rentals among stations across the whole system. Research into past years' bike rental data showed that the overall demand increased during warmer months and decreased during colder months. Therefore, Goldbeck questioned whether ridership patterns within different seasons for the past two years also followed a similar trend. He was equally curious to find out how seasonality affected Capital Bikeshare's business and when the best time of the year would be for a promotion strategy to boost demand and encourage the use of Capital Bikeshare's bikes.

On a per-day basis, Goldbeck also knew that while the flow of commuters was approximately balanced over the course of a day, ridership patterns could be changed by a variety of external factors, such as temperature and weather conditions, that would cause the flow of bicycles to behave differently. Therefore, Goldbeck wondered how these factors affected users' riding decisions and how different timing would affect the system's operations.

LOOKING AHEAD

With radio-frequency identification, global positioning system technology, and an adequate artificial intelligence system, the system's data would continually become more accurate as more Capital Bikeshare users entered and exited the system. Goldbeck knew that invaluable insights about ridership patterns were embedded in the collected data, and he needed answers before he could develop a sound strategic expansion plan.

[13] Data was collected through "System Data," Capital Bikeshare, accessed August 24, 2020, https://www.capitalbikeshare.com/system-data.

EXHIBIT 1: SELECTION OF HISTORICAL DATA FOR CAPITAL BIKESHARE DEMAND

year	month	day	hour	member	weekend	season	temperature	dewpoint	humidity	windspeed	windgust	pressure	precip	precipaccum	weather	rental
2016	10	1	0	80	1	fall	18.33	65	100	6	0	30.1	0	0	3	103
2016	10	1	1	53	1	fall	17.78	64	100	10	0	30.1	0	0	3	63
2016	10	1	2	27	1	fall	17.78	64	100	10	0	30.1	0	0	3	33
2016	10	1	3	20	1	fall	17.78	64	100	10	0	30.1	0.1	0	3	23
2016	10	1	4	11	1	fall	17.78	64	100	9	0	30.1	0	0	3	11
2016	10	1	5	14	1	fall	17.78	64	100	9	0	30.1	0	0	3	15
2016	10	1	6	38	1	fall	17.78	64	100	12	0	30.1	0	0	3	42
2016	10	1	7	104	1	fall	17.78	64	100	13	0	30.1	0	0	3	115
2016	10	1	8	133	1	fall	17.78	64	100	14	0	30.1	0	0.2	3	146
2016	10	1	9	145	1	fall	17.78	63.5	98	9	0	30.1	0.05	0	3	174
2016	10	1	10	228	1	fall	17.78	63.5	98	8.75	0	30.1	0.08	0	3	272
2016	10	1	11	353	1	fall	18.61	64.5	96.5	10	0	30.1	0	0	2	477
2016	10	1	12	382	1	fall	18.89	65	96	8	0	30.1	0	0	2	562
2016	10	1	13	286	1	fall	18.89	65.2	96.8	8	0	30.1	0	0	4	416
2016	10	1	14	326	1	fall	19.31	66	97.75	9.75	0	30.1	0	0	3	463

Source: Created by the authors using data from "System Data," Capital Bikeshare, accessed October 1, 2018, https://www.capitalbikeshare.com/system-data.

EXHIBIT 2: DESCRIPTIONS OF DATA

Feature	Description
year	Year
month	Month
day	Day
hour	Hour of the day (using the 24-hour system)
member	Number of registered user rentals initiated
weekend	Whether the day is a weekend
season	Season (spring, summer, fall, or winter)
temperature	(in °C)
dewpoint	Relative dew point
humidity	Relative humidity
windspeed	Wind speed (in mph)
windgust	Wind gust (in mph)
pressure	Pressure (kPa)
precip	Precipitation (in inches)
precipaccum	Precipitation Accumulation (in inches)
weather	1: fair; fair/windy; partly cloudy; partly cloudy/windy 2: mostly cloudy; mostly cloudy/windy; cloudy/cloudy windy; mist; shallow fog 3: light drizzle; light rain; light rain with thunder; light sleet/windy; light snow/windy; rain/windy; light drizzle/windy; light rain/windy; light sleet; light snow; light snow and sleet/windy; rain 4. haze; heavy rain/windy; patches of fog; snow; squalls/windy; thunderstorm/windy; thunder/windy; wintry mix; heavy rain; fog; heavy thunderstorm; snow and sleet; thunderstorm; thunder; thunder in the vicinity; wintry mix/windy
rental	Number of total bike rentals

Note: °C = degrees Celsius; mph = miles per hour; kPa = kilopascal.
Source: Created by the authors.