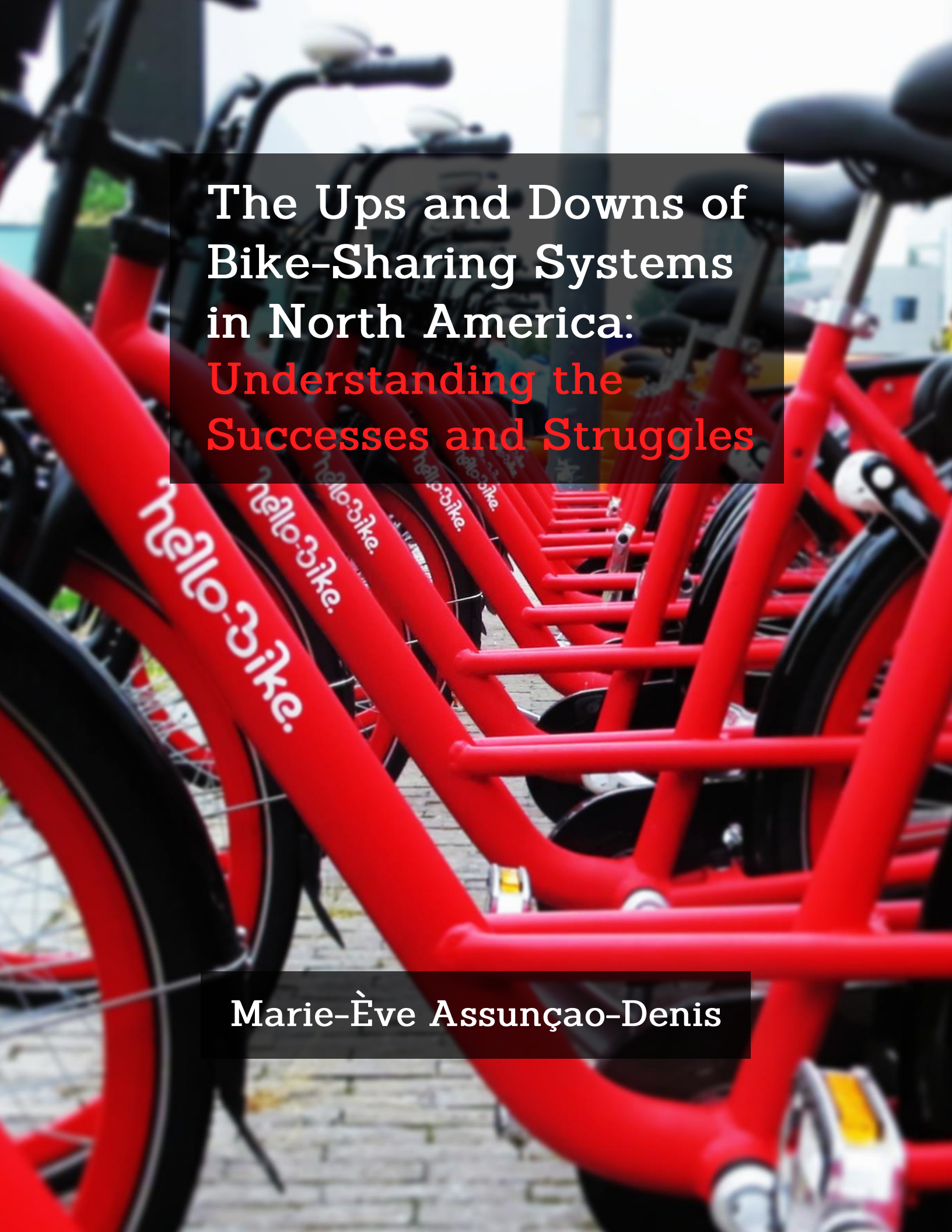

The Ups and Downs of Bike-Sharing Systems in North America: Understanding the Successes and Struggles

Marie-Ève Assunçao-Denis

Cover picture: Hello-Bike bike-sharing system, Amsterdam
Photo credit: Marie-Ève Assunçao-Denis, 2017

The Ups and Downs of Bike-Sharing Systems in North America:

Understanding the Successes and Struggles

Supervised Research Project

Written by Marie-Ève Assunçao-Denis

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– Marie-Ève


hello-bike.
hello-bike.
hello-bike.
hello-bike.

ABSTRACT

In the past ten years, bike-sharing systems have spread across the world, becoming popular in both large and smaller cities. Some systems have attracted high ridership levels and are popular amongst the population they serve. Others have been struggling from their inception or have had to contend with major obstacles along the road. What makes some of these systems successful while others are not? What can municipalities do to ensure that their future or current system are successful? Are there recurring patterns in the death and life of bike-sharing systems?

This study looks at the factors that have been associated or have contributed to the success or failure of four specific bike-share systems in North America: Montreal's BIXI, New York City's Citi Bike, Seattle's Pronto! and DECOBIKE San Diego. First, this study proposes a review of the history, types, and business and financial models of bike-sharing systems. It then looks at the systems' functioning, users, and goals, as well as benefits and challenges associated with some or most systems. Then, the four case studies are analysed in depth to find factors that were instrumental in their success or failure. Two of them, Montreal's BIXI and New York City's Citi Bike, were chosen based on their successes in terms of ridership numbers and popularity amongst local residents. The two other cases, Seattle's Pronto! and DECOBIKE San Diego, were selected for the struggles they have encountered since their beginnings, be they financial problems, mismanagement issues and/or low ridership numbers.

Findings show that all four case studies have encountered challenges and difficulties, but some of them were luckier or better prepared to manage the problems. Factors that were found to be helpful for the success of a system include: having a dense and large system in terms of coverage, number of stations and fleet size; getting political, administrative and community support; receiving public funds and sponsorships; not having a mandatory bike helmet law; including the City, public and other stakeholders in the planning and implementation processes; hiring a competent and financially viable operator company; monitoring the system and its operations, and sharing the data with the public; being transparent; creating partnerships with other transportation agencies to increase inter-modality; implementing stations in transportation hubs as well as residential neighbourhoods and popular destinations; expanding the system to access new neighbourhoods and populations; having a flexible system that can respond to the demand; creating cycling infrastructure; taking into account environmental and contextual conditions when designing the system and the program; defining the audiences and adapting the system and its marketing strategies for them; using technology to make the system more efficient and flexible; offering many usage and payment options, as well as discounts for vulnerable populations; focusing on commuters and utilitarian cycling; and interfering as little as possible with local bike rental shops' businesses.

RÉSUMÉ

Au cours des dix dernières années, les systèmes de vélos en libre-service ont connu une croissance fulgurante à travers le monde, et leur popularité est observable non seulement dans les grandes villes mais également dans les plus petites villes. Certains systèmes ont su engendrer des taux élevés d'achalandage et connaissent une popularité auprès des communautés qu'ils desservent. D'autres, en revanche, ont éprouvé des difficultés dès leurs balbutiements ou ont rencontré des obstacles majeurs en cours de route. Qu'est-ce qui explique le fait que certains systèmes soient couronnés de succès tandis que d'autres ne le sont pas? Que peuvent faire les municipalités afin d'assurer le succès de leur système actuel ou futur de vélos en libre-service? Existent-ils des modèles ou facteurs qui réapparaissent constamment dans le déclin et la survie des systèmes de vélos en libre-service?

Cette étude porte sur les facteurs ayant contribué au succès ou à l'échec de quatre systèmes de vélos en libre-service en Amérique du Nord: BIXI à Montréal, Citi Bike à New York, Pronto! à Seattle et DECOBIKE San Diego. Cette étude propose, en premier lieu, une revue de l'histoire, des types et des modèles commerciaux et financiers de systèmes de vélos en libre-service. Les sections suivantes portent sur le fonctionnement, les utilisateurs et les objectifs des systèmes, ainsi que les avantages et défis associés à certains ou à la plupart des systèmes. Les quatre études de cas sont par la suite analysées en profondeur afin d'identifier les facteurs ayant pu jouer un rôle décisif dans leur succès ou échec. Deux de ces cas, BIXI à Montréal et Citi Bike à New York, ont été choisis pour leurs taux élevés d'achalandage et de popularité auprès des communautés locales. Quant aux deux autres cas, Pronto! à Seattle et DECOBIKE San Diego, ils ont été sélectionnés en raison des enjeux auxquels ils ont dû faire face depuis leur tout début, que ce soit à cause de problèmes financiers, de mauvaise gestion et / ou à cause d'un faible taux d'utilisation du système.

Les résultats montrent que les quatre systèmes de vélos en libre-service ont fait face à des défis et des difficultés, mais que certains d'entre eux ont été plus chanceux ou mieux préparés afin de gérer ces enjeux. Les facteurs jugés les plus pertinents dans le succès d'un système de vélos en libre-service comprennent: la mise en place d'un réseau large et dense en termes de superficie, de couverture du territoire, ainsi que de nombre de stations et de vélos; l'obtention d'un soutien politique, administratif et communautaire; l'obtention de fonds publics et de commandites; l'absence de loi obligeant le port du casque à vélo; l'inclusion de la Ville, du public et d'autres parties prenantes dans les processus de planification et de mise en œuvre du projet; l'embauche d'une compagnie opératrice compétente et financièrement viable; la surveillance du système et de ses opérations, ainsi que le partage des données collectées avec le public; l'obligation des diverses parties prenantes à faire preuve de transparence; la création de partenariats avec d'autres agences de transport afin de favoriser

l'intermodalité; l'installation de stations dans les lieux névralgiques en matière de transport, ainsi que dans les quartiers résidentiels et les destinations populaires; l'élargissement du système afin d'atteindre de nouveaux quartiers et rejoindre de nouvelles communautés; la création d'un système flexible pouvant répondre à la demande; la construction ou l'amélioration des infrastructures cyclables; la prise en compte des conditions environnementales et contextuelles lors de la conception du projet et du système; la définition du ou des publics cibles et l'adaptation du système et des stratégies de vente et de promotion en fonction de ceux-ci; le recours à la technologie afin d'augmenter l'efficacité et la flexibilité d'un système; l'offre de nombreuses options d'utilisation et de paiement, ainsi que de réductions pour les populations plus vulnérables; le développement et l'ajustement du système en fonction des résidents utilisant le vélo à des fins utilitaires, et un nombre minimum d'interférences avec les commerces locaux de location de vélos.

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LIST OF DEFINITIONS

ITDP: Institute for Transportation and Development Policy

NACTO: National Association of City Transportation Officials

PBSC: Public Bike System Company

PSBS: Puget Sound Bike Share

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CHAPTER 1:
INTRODUCTION

Cycling has increased considerably in cities across North America in the last two decades. The City of Montreal, for instance, has seen its number of daily riders increase by 57% between 2008 and 2013, and cycling trips in New York City tripled in the past fifteen years to reach 400,000 daily trips in 2016 (New York City's Department of Transportation, 2016; Vélo Québec, 2016). Considering the undeniable virtues of cycling, from health benefits to positive environmental impacts, it is not surprising that several municipalities have made tremendous efforts to promote utilitarian biking and create a better and safer environment for cyclists. Indeed, cycling uses less non-renewable energy than vehicle-driven options, and helps reduce air and noise pollution, while also occupying far less space on the roads than cars and other vehicles. Biking also has direct impacts on cyclists by allowing them to include physical activity into their daily routine, which can help prevent health issues such as diabetes, obesity, and cardiovascular diseases. Moreover, cycling has financial advantages, since biking infrastructure costs significantly less than car and public transit infrastructure. It is also one of the least expensive options for users, compared to the cost of a car or a transit pass. All these points make cycling one of the most sustainable, affordable, and socially equitable modes of transport accessible to everyone (Garrard, Rissel & Bauman, 2012; Pucher & Buehler, 2012).

One of the latest trends used by cities to encourage cycling is the adoption of a bike-sharing system. Not only do these systems help to increase cycling's visibility within cities, but they also provide a new public transport option for citizens wishing to reach destinations and make point-to-point trips. They offer a solution to the "first/last mile" problem and thus, are a good complement to the transit offer. They also contribute to making transit more attractive. Since the inauguration of the now defunct *Witte Fietsen* (White Bike) in Amsterdam in 1965, bike-sharing systems have greatly evolved and can be classified into four or five different generations today (Cichosz, 2013; DeMaio, 2009; Mátrai & Tóth, 2016; Shaheen, Cohen & Martin, 2012; Shaheen, Guzman & Zhang, 2010). In the last few years, technology has allowed the spread of smart, dockless bike-sharing schemes whose bicycles can be parked not only at dock stations but in any allowed public space, making dock stations optional. This has increased the flexibility of bike-sharing systems even further, while the reduction in implementation and operational costs have made them more affordable and accessible to cities (Cichosz, 2013; CycleHop, 2016 & n.d.; Motivate International Inc., 2016a; Social Bicycles Inc., 2017). These dockless systems have created opportunities for private bike-sharing start-up companies, whose rapid expansion has caused a saturation and overconsumption of bikes in some Asian cities. This trend is revolutionizing the concept and reality of bike-sharing systems (Douglas, 2013; Kolodny,

2017; Larsen & Dissing Christensen, 2015; Lloyd, 2017e; Meddin & DeMaio, 2017; National Association of City Transportation Officials [NACTO], 2017c).

As of May 2017, bike-sharing systems have been implemented in more than a thousand cities around the world, and more than 300 new systems are planned for the upcoming years (Gutman, 2016; Meddin & DeMaio, 2017; Schuijbroek, Hampshire & van Hoeve, 2017). Some of them, like Paris' Vélib', Barcelona's Bicing and New York City's Citi Bike, have attracted high ridership and significant popularity (Institute for Transportation and Development Policy [ITDP], n.d.; Basch & al., 2015). In contrast, other systems have been struggling from their inception or have witnessed major obstacles along the way. For instance, the City of Seattle shut down its Pronto! bike-sharing system on March 31, 2017, after a two-and-a-half-year period marked by low ridership levels and financial mismanagement (Robertson, 2017). Another system, Montreal's BIXI, has encountered both success in terms of ridership and financial struggle throughout its eight-year history, demonstrating the ups and downs of public transportation systems (Faghih-Imani & al., 2014; Goodyear, n.d.; Messahel, 2016; Strini, n.d.).

What allowed some of these systems to navigate their way towards success, while others seemed doomed from the start? Are there specific political, economical, social, geographical or organizational factors that can encourage or act as barriers to the success of a bike-sharing system? What can municipalities do to ensure that their future or current system is successful? Is there a type or model of bike-sharing system that is more successful than others? Are there recurring patterns in the death and life of bike-sharing systems?

This study will look at factors associated or contributing to the success or failure of four specific bike-share systems in North America: Montreal's BIXI, New York City's Citi Bike, Seattle's Pronto! and DECOBIKE San Diego. First, we will review in detail the history, types, and business and financial models of bike-sharing systems, as well as their functioning, users, goals, and the benefits and challenges associated with some or most systems. Then, the four case studies will be analysed in depth to find the instrumental factors in their success or failure. Two bike-sharing systems, BIXI and Citi Bike, were chosen for their success in terms of ridership numbers and popularity amongst local residents. The two other cases, Pronto! and DECOBIKE San Diego, were selected for the struggles they encountered, from financial problems, to mismanagement issues and low ridership numbers. In-depth analyses were conducted to understand the main factors that influenced the history and outcomes of these bike-sharing systems. Based on the analyses' conclusions, we formulate recommendations for municipalities and firms looking to implement a new bike-sharing system or transform an existing one. These recommendations can be found in the last chapter of this study.

CHAPTER 2:
THE BASICS OF BIKE-SHARING

A bike-sharing system can be described as the "shared use of a bicycle fleet" within an urban setting (Shaheen et al., 2012). Midgley (2011) provides a more comprehensive definition of the concept, a flexible "short-term urban bicycle rental scheme that enables bicycles to be picked up at any self-serve bicycle station and returned to any other bicycle station," making the system perfect for point-to-point, or origin-destination trips. This definition may be called upon to change with the recent introduction and expansion of dockless schemes, which provide even greater flexibility in terms of accessibility to bicycles and destinations. Therefore, a more actual and wider definition could be a short-term urban bike rental service featuring a network of self-service bikes which can be returned to any allowed location and are accessible through a mobile app or Wi-Fi technology.

Other important aspects of public bike networks include their low cost of use and the fact that they allow citizens to instantly access a bicycle without having to deal with the costs and responsibilities linked to owning a bicycle (Midgley, 2011; NYC's Department of City Planning, 2009; Shaheen et al., 2012). There are different groups of target users, from annual registered members to occasional or casual riders. The system is located on public spaces (Mátrai & Tóth, 2016; Ricci, 2015). The development and expansion of these bike-sharing systems has led to the emergence of a mainstream and environmentally-friendly form of public transportation for daily commuting and utilitarian trips (Midgley, 2011; Shaheen et al., 2010).

The system carries different names, depending on the type of literature (academic, professional, governmental) and geographical area. Such names include public-use bicycles (PUBs), bicycle transit, bicycle-sharing or bikeshare scheme (commonly used in North America), cycle hire (in the United Kingdom), bike hire, cycle sharing (in South Asia), smart bikes, as well as public bicycle or public bike sharing – or PBS – (especially in China) (ITDP, n.d.; Mátrai & Tóth, 2016; Midgley, 2011; Ricci, 2015).

In the next section, we will look into the history and spread of the bike-sharing phenomenon, from its start in the 1960s up to today's global boom. We will first assess the characteristics of the four main bike-sharing scheme generations. Then, we will discuss the latest trends in the field, with a special focus on smart dockless bikes, whose emergence and rapid expansion, notably in Asia and North America, are changing the game in the bike-sharing market worldwide. Thirdly, we will examine the history and current situation of bike-sharing programs in North America, looking at the spread of systems and today's main schemes. The last sections of this chapter will describe the different business and financial models, as well as the implementation and operation processes of cycle hires around the world.

2.1. History and generations of bike-sharing systems

As of May 1st, 2017, bike-sharing systems can be found in more than 1,286 cities around the world, with approximately 3,415,750 public use bicycles or pedelecs[1] accessible to local populations and visitors (Gutman, 2016; Meddin & DeMaio, 2017). These numbers include automated, advanced automated, and mixed automated/staffed systems, as well as official bike-share schemes and what some authorities call "rogue" bike-share companies (see section 2.1.2) (Meddin & DeMaio, 2017; National Association of City Transportation Officials [NACTO], 2017c). Since the inception of the first bike-sharing system in Amsterdam in 1965, cycle schemes have expanded and mushroomed worldwide. With the launch in November 2016 of Marrakesh's Medina Bike, Africa's first bike-sharing system, they are now present on every continent with the exception of Antarctica (Bryce, 2016; Meddin & DeMaio, 2017; Shaheen et al., 2012). Cycle schemes are also present across several work and educational campuses around the world. In most cases, stations are located on campus or in close proximity, and can be used anywhere in town, including outside of campus, but must be returned to a campus dock station. A few examples of such institutions are: Monash University, in Australia; the Universidad Autonoma de Madrid (UAM), in Spain; and Princeton University and the University of Virginia in the United States (Kelly, 2016; Monash Bikeshare, n.d.; Shaheen et al., 2010; University of Virginia Parking and Transportation, n.d.). In 2016, the University of Nairobi in Kenya started a bike-share pilot program on its campus which garnered attention from the media for being one of the first of its kind on the African continent (Mwanza, 2016). As of 2015, three out of four of the world's bike-sharing systems were in China (Goodyear, 2017). According to Meddin (2017), at the end of 2016, there were 121 systems in North America, 34 in South America, 524 in Europe, 1 in Africa, 6 in Oceania, and 502 in Asia, including 430 in China alone. Of the 15 biggest schemes around the world in March 2017, 13 are located in China. The two others are Paris' Vélib', ranking fifth with 21,000 bikes, and London's Santander Cycles, ranking twelfth with 16,500 bikes. In comparison, the largest system in the world, located in Hangzhou, comprises of 84,100 bicycles (Van Mead, 2017).

2.1.1. Four main bike-sharing categories

There are currently four main categories of bike-sharing systems, as well as an emerging new fifth generation.

[1] Pedelec : bicycle with an electric motor whose assistance can be activated by the pedaling movement (Meddin & DeMaio, 2017)

Generations	Description
1st generation: the White Bikes	- Free to use - Unlocked bikes (in many cases) - No docking station
2nd generation: the coin deposit system	- Docking stations - Check-out by inserting coins - No time limit for borrowing bikes - Custom-built, distinguishable bikes - More measures to counter theft and vandalism - More reliable and secure system
3rd generation: the IT-based system	- Information technologies (magnetic striped cards, smartcards and smart keys) - Better services (pick-up, drop-off, reservations, payments) - ID card or bank card necessary to borrow (accountability, deposit to discourage theft and vandalism) - Real-time information (websites, bike availability, tracking through GPS – in some systems) - First determined time interval is free, then cost increases gradually - More developed, anchored docking stations - Custom-built, distinguishable bikes (advertisement, design, colour)
4th generation: the complex, integrated demand-responsive system	- More advanced technology for increased flexibility - Modular, flexible, solar-powered stations - First generations of dockless bikes - Demand-responsive redistribution innovations to ease rebalancing (value pricing for self-rebalancing, bonus malus, etc.) - Multi-modality and billing integration (shared smartcards, real-time transit integration, system data dashboards etc.) - Access to bike through mobile device (for paying and accountability) - More environmentally-friendly technologies (electric bikes, solar-powered stations, cargo bikes or electric vehicles for redistribution)
5th generation: dockless and smart bikes	- New technologies (pedelecs, smart bikes, dockless bikes) - Emergence of dockless "rogue" systems (created by start-up companies) - Different business approaches and sometimes "aggressive practices" - First start-ups appeared in Asia and started to spread in North America in 2017 - Led to saturation in number of bikes in some cities in Asia

Table 1: Bike-sharing generations. Source: DeMaio, 2009; Fitzgerald Rodriguez, 2017; ITDP, n.d.; Mátrai & Tóth, 2016; Meddin, 2017; Midgley, 2011; NACTO, 2017c; Normandin, 2017; Shaheen et al., 2010; Shaheen et al., 2012; Van Mead 2017; Walsh, 2017

First generation: the White Bikes

The first generation appeared in July 1965, when the City of Amsterdam and the non-profit organization Provos introduced fifty ordinary bicycles all painted in white, as a way to fight traffic within the town centre. These *Witte Fietsen* (White Bikes) were free to use and placed unlocked throughout the Inner city for people to use. The program came to an end within days after its launch (DeMaio, 2009; Shaheen et al., 2010). Most bikes were stolen or damaged, and some bikes were thrown into canals. However, it set the stage for other cities to implement similar bike-sharing programs in the following years. They are referred to today as the White Bikes or Free Bike Systems, the first generation of bike-share schemes. With these programs, the only component were the bicycles, which were painted in one bright colour and left unlocked in random places for free public use. In a few systems, bikes were locked and, although their use was free, users had to request a key from participating local businesses and could be asked to leave a credit card deposit. Other cities implemented similar programs, with some "still operating as community-based initiatives" as of 2012 (Shaheen et al., 2012; Shaheen et al., 2010). For instance, Cambridge in the UK launched its Green Bike Scheme in 1993, but the program failed due to the theft of most of the fleet of 300 bicycles. La Rochelle, in France, implemented a system in 1974 called *vélos jaunes* (yellow bikes), which received strong support from citizens and proved to be successful. It was still operating in June 2009 when the City of La Rochelle introduced a fourth-generation bike-sharing system named Yélo (contraction of "yellow" and *vélo* – "bike" in French) in honor of those yellow bikes. This fully-automated system uses smartcards connected to other public transportation networks (Communauté d'Agglomération de La Rochelle, 2009; Shaheen et al., 2010).

Second generation: the coin-deposit system

The second generation of bike-sharing systems tried to address the problem of bike theft which proved to be the greatest challenge faced by the first generation. While small systems were implemented in the Danish towns of Farsø and Grenå in 1991 and Nakskov in 1993, it is in January 1995 that the "first large-scale urban bikesharing program in Europe" was launched by the City and City Bike Foundation of Copenhagen, in Denmark (DeMaio, 2009; Shaheen et al., 2010). The system, called Bycyklen (City Bike), had 1,100 specially designed bicycles locked at designated public bike racks in the downtown area. To use a bike, a 20 Danish krone coin had to be deposited (the equivalent of US$3) and was refunded upon the bike's return. This system, which in 2010 counted more than 2,000 bicycles and 110 city racks, was in operation until it was replaced by a fourth-generation electric bicycle system, also called Bycyklen, in August 2015 (GoBike, 2014a & 2015; Shaheen et al., 2010). The 1995 version was the first model of second-generation cycle schemes, called coin-deposit systems. These are characterized by distinguishable custom-

built bikes, with a unique colour, a "heavy-duty" design aimed at intense utilitarian use – the Bycyklen have solid "tires and wheels with advertising plates" – and non-standard components to deter theft. Systems also have designated docking stations/parking locations where bicycles are locked, picked up, and returned. Small coin deposits, usually not more than US$4, are required to borrow a bike (DeMaio, 2009; Midgley, 2011; Shaheen et al., 2010). These systems proved to be more reliable, secure, formalized, dependable, and vandalism- and theft-resistant, while still being simple and inexpensive to install. Despite these new features, second-generation bike-sharing systems remained vulnerable to some issues, especially theft and vandalism. Indeed, the low coin deposit fees, the absence of a time limit for each lending, and customer anonymity led users to borrow bikes for long periods of time or simply not return them since they there was no accountability mechanism. In the years following the implementation of the Bycyklen system in Copenhagen, other cities in Europe adopted similar systems, such as Sandnes in Norway in 1996, Helsinki in Finland in 2000, and Arhus in Denmark in 2005. In many cases, the administration and management of the programs were given to non-profit organizations which received government funding (DeMaio, 2009; ITDP, n.d; Midgley, 2011; Shaheen et al., 2012; Shaheen et al., 2010).

Third generation: the IT-based system

The third generation of bike-sharing systems is characterized by the implementation of information technologies such as magnetic striped cards, smartcards, and smart keys. This contributed to improving customer tracking and therefore deterring bike theft and vandalism. IT features diminish issues encountered by previous generations related to users' anonymity (DeMaio, 2009; Midgley, 2011; Shaheen et al., 2010). Advanced technologies allow for more developed services in terms of pick-up, drop-off, and bike reservations, while the introduction of GPS in some systems permits the tracking of users and trip information. A network of self-service stations can "communicate with a central computer system [while also using] Radio Frequency Identification (RFID) technology to monitor the location of bicycles in the system" (NYC's Department of City Planning, 2009). This generation also saw the introduction of websites for users to access real-time information, such as bike availability at docking stations (Midgley, 2011). Third-generation bike-sharing systems include customized bicycles with specific colours, advertisement or design; docking stations; and "kiosk or user interface technology for check-in and check-out" as well as for payments (Shaheen et al., 2010). Members of the programs are required to provide an ID card or bank card. This ensures accountability in the case of the non-return of a bike. Members who do not comply are charged the cost of a new bicycle and may also have to deal with important punitive fees. For users who are not members, a sizeable deposit usually has to be paid prior to

borrowing a bike, which encourages users to return bicycles to recover the deposit (Midgley, 2011; Shaheen et al., 2010). Members usually have access to the service at no cost during a specified time interval, for instance the first 30 minutes. Beyond the specified time, costs for the bicycle increase gradually based on the amount of time it is in use.

Third-generation bike-sharing systems started in Europe with Bikabout in 1996 at Portsmouth University in England. Access to bikes was provided to students through the use of a magnetic stripe card (DeMaio, 2009; Shaheen et al., 2010). This generation is often characterized by public-private partnerships. Private partners can include advertising companies, which are in charge of implementing and operating the scheme in exchange for free billboard advertising. This was the case for Clear Channel, which in 1998 launched the SmartBike program, more commonly called *Vélo à la carte*, in Rennes, France, which would be the first of a series of similar systems. This IT-based system relied on the use of smartcards which were required in order to have access to a bicycle at no cost for up to three hours. The program worked up to 2009, when it was replaced by another third-generation system, LE vélo STAR (Keolis, n.d.; Shaheen et al., 2010). Vélo'v in Lyon, France, is the scheme that popularized IT-based systems. It was launched by the advertising company JCDecaux in 2005 with 1,500 bicycles. Today, the system, still operated by JCDecaux, has more than 4,000 bikes across 348 stations in Lyon and Villeurbanne. The system is open at all time and accessible to people above 14 years of age. Users have access to a touchscreen to register and select different fees (DeMaio, 2009; Métropole de Lyon, n.d.b). The first 30 minutes are free, and special offers include youth prices and professional programs for businesses or institutions wishing to increase biking amongst their employees or members. Single-use and annual fees are kept low, which makes the system attractive. For instance, in May 2017, an annual membership cost €25, versus €1.50 for a 24-hour ticket, €3 for a 3-day card, and €5 for 7-day tickets (Métropole de Lyon, n.d.c). Inspired by Vélo'v, Paris launched in 2007 its Vélib', which is today considered one of the most famous third-generation bike-sharing systems worldwide (Shaheen et al., 2010). Stations are located every 300 meters and are available all year long. Like Vélo'v, Vélib' offers the first 30 minutes of use at no cost and its pricing is very competitive: a 1-day pass cost €1.70 in May 2017, and a 1-week pass, €8. The annual membership varies between €19 and €39, with several options including the first 45 minutes free (Mairie de Paris/SOMUPI, 2010b). With 20 million trips made with the Vélib' bikes during its first year of activity alone, and an average of 78,000 trips daily, the popularity of the system created a need to put in place efficient operations regarding the redistribution and maintenance of bikes (Shaheen et al., 2010).

Third-generation bike-sharing systems mushroomed around the world during the 2000s, making their entry in other markets such as North America and Asia. Tulsa

Townies, in Oklahoma, USA, was the first third-generation bike-sharing program launched in North America in 2007, as well as the first solar-powered bike-share program in the world (Moennick, n.d.; Saint Francis Health System, n.d.; Shaheen et al., 2012). Washington D.C.'s pilot program, SmartBike, was released not long after, in 2008. It was one of the first IT-based systems in North America, but came to an end quickly and was replaced by a more sophisticated fourth-generation model, Capital Bikeshare, in 2010 (Ahillen, Mateo-Babiano & Corcoran, 2016). In South America, bike-sharing systems were first implemented in 2008 in Brazil. In Asia, Singapore led the way with TownBike, also known as Smart Bike, which operated between 1999 and 2007. Bike-sharing programs have been rapidly expanding in the region since, making Asia the fastest growing bike-sharing market in the world (Shaheen et al., 2010). In 2013, the number of bike-sharing schemes in the world increased by 60 percent, thanks to 65 new cycle schemes in China alone (Goodyear, 2017).

Fourth generation: the complex, integrated demand-responsive system

While third-generation cycle schemes were mainly characterized by the advent of technology in the bike-sharing market, fourth-generation schemes went further with the development of more advanced technology, thus providing increased flexibility. The distinction between third- and fourth-generation systems is blurry in grey and academic literature, with several authors combining all IT-based systems in one sole generation. Those drawing a distinction describe fourth-generation systems as being "demand-responsive, multi-modal systems built upon the technology of third-generation systems by implementing enhanced features, such as flexible, clean docking stations or dockless bicycles; demand-responsive bicycle redistribution innovations to facilitate system rebalancing; value pricing to encourage self-rebalancing; multi-modal access; billing integration (e.g. sharing smartcards with public transit and carsharing); real-time transit integration and system data dashboards; and global positioning system (GPS) tracking" (Shaheen et al., 2012). Bikes can be accessed through a mobile device, which serves to identify the user and make payments. Advanced technologies, combined with the fact that most people have easy access to mobile phone applications, allow for greater data collection and real-time information, such as knowing the exact trajectory used by a user or real-time bike availability. The demand-responsive approach includes bonus-malus systems to attract users towards stations where there is a lack of bicycles. This incentivizes users to participate in the redistribution of bikes, with the aim of making the program more efficient and cost-effective. For instance, users can be given bonuses when moving in the opposite direction of the regular flow during specific times, or when reaching stations which see more departures than arrivals. Exiting downtown during morning peak times or going up a hill are good examples of trips targeted for bonuses.

Modularity is an important feature of this generation. With prior generations, most stations were permanently anchored to the ground, with wires connecting them to the nearest underground power source, which required excavation and trenching. This made implementation time-consuming and costly. New modular docking stations can be adapted to the context and moved according to demand, thanks to constantly improving battery technology. For instance, Montreal's BIXI wireless station models include modules with a pay kiosk and others with docking spaces only. By adding one or more docking modules to a kiosk module, planners can optimize the system by adjusting station size based on local demand patterns. Modular stations can also be easily removed during winter months, which is the case of BIXI in Montreal (ITDP, n.d.; Mátrai & Tóth, 2016; Midgley, 2011).

Fourth-generation systems include more and more environmentally-friendly technologies, such as partially or fully electric bikes and solar-powered docking stations. It also includes the use of cargo bikes or electric vehicles for bike redistribution. The level of integration with other urban and transportation mode systems is also primordial. For instance, some systems use the same rechargeable user card as other public transit systems, and bike-sharing fares are integrated into the public transit fare offer. For instance, in Hangzhou and Guangzhou, China, one universal card provides access to the bike-sharing system, buses, bus rapid transit (BRT), and metro systems (ITDP, n.d.; Mátrai & Tóth, 2016; Midgley, 2011). In Austria, the Vienna Mobility Card is a multimodal transportation card which includes, for a €12 supplement to the annual transit pass, a bike-sharing access card, a carsharing membership, cash-free taxi payments, as well as discounts on e-mobility charging cards and the city-airport train (Lindinger, 2017). One of the most popular fourth-generation bike-sharing systems is Montreal's BIXI (a contraction between the words "BIcycle" and "taXI"), whose modular stations and award-winning bicycle model have been replicated in other major cities around the world (Cooper, 2009). For instance, Washington, D.C.'s Capital Bikeshare, London's Santander Cycles (formerly known as Barclays Cycle Hire or Boris bikes), New York City's Citi Bike, Melbourne Bike Share, Minneapolis' Nice Ride Minnesota, Boston's Hubway, Toronto Bike Share, San Francisco's Bay Area Bike Share (now called Ford GoBike as of summer 2017), Chicago's Divvy, and Guadalajara's MiBici in Mexico are all using BIXI's modular station and bike models created by the Montreal-based Public Bike System Company (PBSC) (Goodyear, 2017; Motivate, 2016; Motivate International, Inc., 2017a; PBSC Solutions Urbaines, 2017).

2.1.2. A fifth generation? The emergence of new technologies and dockless systems

In the past five years, new technologies have made bike-sharing systems take an additional step forward with the introduction of smart bikes, pedelecs (electrically-assisted bikes), and dockless bicycles. At the end of 2016, approximately 11,000 pedelecs and 550,000 dockless bikes were in service worldwide, and the number of dockless bikes is increasing every day (Meddin, 2017; Van Mead 2017). This section will present the concept, types, and recent explosion of dockless bike-sharing systems, as well as touch on new technologies that have contributed to the spread of smart bikes.

Copenhagen's new Bycyklen system fleet is made of pedelecs and provides a good example of the latest trend in smart bike technology. Each bike has a lithium-ion battery which, when fully charged, provides assistance for up to 25 kilometers based on factors like terrain, weather, riding style, and abilities. There is also a 250-Watt electric motor on the front wheel, which can reach "up to 22 km/hour, and automatically switches off when the brakes are in use." Next to the handlebar is a touchscreen tablet containing a built-in, weather-resistant GPS, which transmits information to the network system every minute. Finally, a horseshoe lock on the rear wheel is linked to the touchscreen tablet and unlocks only when the correct username and pin code are used (GoBike, 2014b).

Dockless bicycles offer greater flexibility than typical fourth-generation cycle hires since they do not need to be picked up and returned to a dock station. They can be locked anywhere on public land (NACTO, 2017a). They also reduce rebalancing activities by favouring "dynamic self-rebalancing" (Shaheen et al., 2012). All required electronic components are incorporated into the bikes instead of being located at kiosks and dock stations. Most models possess a horseshoe lock on the rear wheel similar to the one found on the new Bycyklen. These locks can be unlocked via the use of a mobile application. For instance, a user can enter a bike unique number into the smartphone app, which will generate a QR code that can be scanned or a combination that can be entered to unlock the bike. All these features allow for the implementation of systems on larger and more flexible areas (Meddin, 2017; NACTO, 2017a & 2017b; Van Mead, 2017; Walsh, 2017).

Figure 1. Horseshoe lock (unlocked on the picture). Source: oBike, n.d.

VeloGO, in Canada's capital Ottawa, illustrates another concept of dockless smart bike. Bikes can be reserved through a mobile application, on a website, or by using the bike's keypad. Each bicycle has a lock which can be opened by entering the user's PIN code on the keypad. While using the bike, the user can decide to take a break and stop the time runner by pressing the "HOLD" button and locking the bike to any rack. The user can continue his or her ride by re-entering the PIN code to unlock the bike. At the end of the ride, the user can lock the bike at one of VeloGO's "convenient hub locations or at any regular bike rack for a small additional fee" (CycleHop, n.d.) This system increases the user's flexibility by allowing for breaks during the trip, making this bike-share scheme not only relevant for short-term commuting and utilitarian trips, but also for leisure and longer trips. In July 2016, Portland, Oregon, launched its own smart bike-share system, BIKETOWN, which was at the time of its launch the largest scheme of smart bikes in the United States. Its bikes are provided by Brooklyn-based Social Bicycles, or SoBi, the same bike supplier than Ottawa's VeloGO. This explains why the two systems' technologies are very similar; BIKETOWN has a GPS tracking system and a U-Lock that can be opened via a prepaid card or mobile app. As in the case of VeloGO, users can leave bikes at designated BIKETOWN racks or, for an additional US$2 fee, lock it at any of the City's 4,000 bike racks located within the service area (Kuntzman, 2017; Small, 2016).

These dockless smart bikes represent, to some extent, a new generation of bike-share schemes, since their new components have a considerable impact on the way the

systems are used and function (Normandin, 2017; Van Mead, 2017). They have become more and more omnipresent in the United States, and as of spring 2017, one in three cycling schemes in the country is said to rely, at least partly, on the dockless smart bike technology, up from zero in 2013 (Kuntzman, 2017). They have also led to the emergence of a new trend within the bike-sharing market: "rogue" smart bike-sharing systems.

This new phenomenon has amplified in the last year and has its roots in Asia, more specifically China, with similar start-ups appearing recently in the United States and the United Kingdom. These new operator companies, often young start-ups, have approached bike-sharing markets with what some have called "aggressive practices" (Normandin, 2017; Van Mead, 2017). These companies' strategy is to invade city streets with their fleet, with limited or no public notification and sometimes without previous discussion or upfront coordination with local authorities. These bike-shares have been nicknamed "Uber for bikes" (Fitzgerald Rodriguez, 2017; NACTO, 2017c; Walsh, 2017). That being said, while many early dockless start-up companies implemented their systems without consulting cities' administrations, more and more companies are now discussing with municipal authorities before launching their systems (New Mobility Group, 2017). Some start-up companies who refuse to be tagged as "Uber for bikes" pride themselves on not using the "Uber approach" and work with municipalities. This is the case of Canadian start-up Dropbike, which launched its dockless system in summer 2017 in Toronto – which already has its Bike Share Toronto system – in partnership with the University of Toronto Students Union (Dropbike, n.d.; Hains, 2017; Villeneuve, 2017).

Figure 2. Dropbike in Toronto. Photo credit: Xiaoli Elaine Guo, 2017.

The Chinese bike-sharing boom

On January 30, 2017, Chinese firm Bluegogo launched its blue dockless bikes in the streets of San Francisco without official permission, causing confusion and anger since the city already had the official Bay Area Bike Share program (now Ford GoBike). The Beijing-based firm, which was inaugurated in November 2016, had, within its first month of activity, launched 70,000 bikes in China. After six months, its system was implemented in five main Chinese cities, with other sources noting its presence in up to 18 cities in the country (Cohen, 2017; Fitzgerald Rodriguez, 2017; Van Mead, 2017). In February 2017, the company closed a US$58 million Series A investment deal with Beijing-based Black Hole Capital (Yap, 2017).

Bluegogo's experience in San Francisco did not go as planned. After dropping thousands of bikes on the city's streets, following its strategy used in China, the company provoked the ire of city leaders and Motivate, the bike-share company which runs the Bay Area Bike Share system. The City requested that Bluegogo obtain a permit in order to rent its bikes from parking spaces. The firm was told that "it could not rent bikes from parking spaces not zoned for retail uses," and therefore was facing "administrative fines and possible police enforcement after violating zoning laws under the purview of the San Francisco Planning Department" (Fitzgerald Rodriguez, 2017). Faced with this situation, Bluegogo decided to remove all of its bikes from San Francisco's streets while it worked on acquiring all permits required by the City in order for them to operate on its territory. Meanwhile, the San Francisco Municipal Transportation Agency has been working on new rules regarding bike-share permits (Fitzgerald Rodriguez, 2017).

Bluegogo seems to have learned from its Californian experience since it proposed a business case to the City of Sydney, Australia, in February 2017. In the case, the company asked for on-street parking locations, access to main train stations, as well as a list of "most traffic-plagued intersections" where bikes could be used to reduce traffic (Needham, 2017). Users of the system would be charged AUD$0.99 per period of 30 minutes. The City had been waiting for the completion of a segregated bike lane network before implementing a bike-sharing system. It had planned to release in mid-2017 a feasibility study to help it make an informed decision (Needham, 2017).

Chinese bike-sharing start-ups have been booming in the past few years, with more than thirty operating firms in the country in May 2017 (Normandin, 2017). Its top three firms alone have attracted US$1 billion in investment between them from September 2016 to April 2017. The firm Mobike, whose current production capability reaches 10 million bikes per year, counts among its investors the "Chinese Internet giant" Tencent as well as Apple's supplier Foxconn (Van Mead, 2017). Bluegogo is in third place, behind

Mobike and ofo, both founded in 2015, but it was the first to enter a western market (Needham, 2017). Since then, other firms have gone down the same path, with ofo launching its scheme in Cambridge, UK, at the end of April 2017, and Mobike launching its system with a fleet of 1,000 bikes in Manchester in June 2017. The arrival of ofo raised concerns within the City of Cambridge's council with regards to the space occupied by the fleet, as well as the potential inconveniences the system could create (Cohen, 2017; Evans, 2017; Van Mead, 2017; Walsh, 2017).

The "hi-tech bike-sharing boom" in China and Asia has a dark side (The Guardian, 2017). Indeed, instead of rescuing traffic-clogged cities from congestion and air pollution, the avalanche of new bikes into the streets has led to a lack of parking spaces. Users have been observed parking bikes off-limits, simply throwing them away, or destroying them after use (The Guardian, 2017; Jiang, 2016). This has caused bikes to be discarded into giant piles, like in the case of Shenzhen, where pictures were taken of 3-meter-high piles of colourful dumped shared bikes (The Guardian, 2017; Normandin, 2017). Residents explained the situation by saying that the bikes were "parked haphazardly by careless users or stacked by local security guards trying to clear narrow residential alleys and footpaths" (The Guardian, 2017). The City's administration has recognized the need to intensify regulation of the bike-share industry to improve traffic and safety conditions (The Guardian, 2017). In Guangzhou, access to destinations like shopping malls and metro stations can even be compromised by the large number of parked bikes, which often block the sidewalks. Other bikes with missing or broken parts or with scratched-off QR codes are thrown to the side of the roads (Van Mead, 2017).

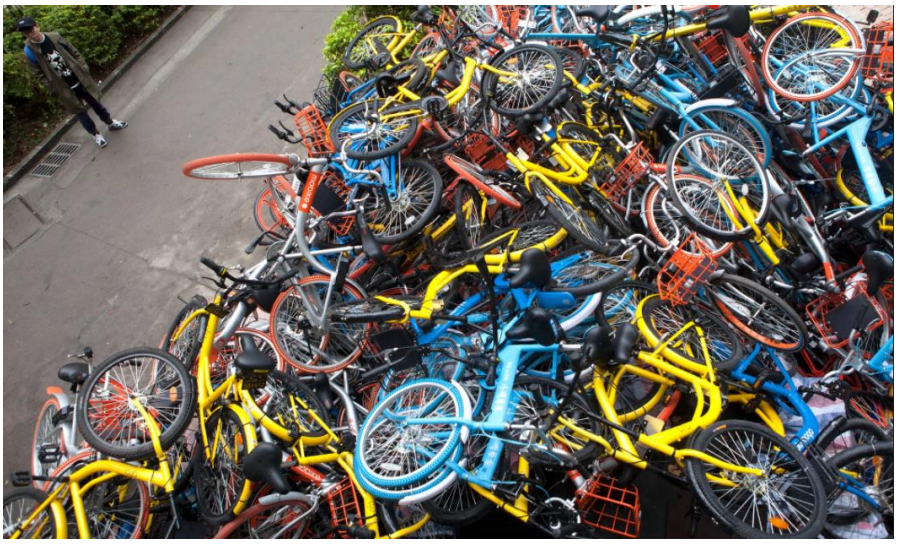

Figure 3. Piles of discarded bikes in Shenzhen. Source: The Guardian, 2017

Figure 4. Confiscated bikes in China. Source: The Guardian, 2017

Another issue with start-up firms is that their expansion relies on competition to attract customers, investments and geographical coverage. Firms busy competing for money and territory may not put the needed efforts in providing good services – including bike maintenance and educating people on where they can park the bikes. In addition, bikes' geographic positions on users' smartphones are sometimes wrong due to inaccurate GPS localization, or because a bike is broken or has been parked in an inaccessible private zone like a residence's courtyard (The Guardian, 2017; Liew, 2017; Van Mead, 2017). As a result, visibility of the systems and bicycles can be lower compared to that of a more traditional scheme with established, highly-visible stations (New Mobility Group, 2017).

Another concern is the low quality of the bikes, which is correlated with low service rates. For instance, ofo's users pay 1 yuan (US$0.15) per hour to rent a bike. According to one of the firm's co-founders, if all their bikes were used four times a day, the bikes' costs could be reimbursed in 2 to 3 months. In the city of Guangzhou, MoBike bicycles are available at 1 yuan per half-hour (Jiang, 2016). With such low fares, it is not surprising to find low-quality, less-resistant bicycles compared to robust models like PBSC's BIXI, which can raise safety concerns. Bike maintenance is also kept to a minimum in the case of start-up bikes, which has consequences on the sustainability of the product and its environmental impact (Normandin, 2017). Indeed, start-ups, whose main goals include profitability, may prefer to save costs by purchasing inexpensive bikes and avoiding bike maintenance and repairs. They may then opt to replace broken bikes with new inexpensive models within a short lapse of time, which might be the most cost-effective option, as described in Larsen & Dissing Christensen (2015). Broken or badly-maintained bicycles end up as waste, thrown away or abandoned, like in Shenzhen and

Guangzhou. Thus, they contribute to pollution and overconsumption, which is the opposite of the usual "environmentally-friendly" image conveyed by cycling schemes (Douglas, 2013; Larsen & Dissing Christensen, 2015).

The National Association of City Transportation Officials (NACTO) issued in April 2017 a press release declaring that "rogue" bike-sharing systems are problematic since they are not integrated with the local public transit offer, which is a crucial part of cycle hires. The organization also had concerns regarding the impact of "rogue" systems on official schemes already in place in North American cities. If the market were to come to saturation following a "flood" of bike-share systems, current traditional systems might not survive. Moreover, these start-ups do not have long-term plans necessarily, and in the event of a potential closure, they risk leaving the market and public transportation offer in worse condition than when they started (NACTO, 2017c; Normandin, 2017). In Singapore, the government decided to abandon its plan of implementing a national bike-sharing scheme after the launch of three dockless bike-sharing systems, local oBike and Chinese ofo and Mobike. Prior to this, the Land Transport Authority had plans to launch a government-run bike-sharing system, which would have comprised of a fleet of around 2,330 bicycles dispersed throughout 300 stations in central areas. In comparison, the three dockless bike-sharing start-ups provide thousands of bikes available at various points across the island. Thirteen local and foreign operator companies had submitted bids for the Singaporean national scheme project, which was looking for an operator and sponsorship consultant and would have been backed by government grants (Abdullah, 2017; Heong Tung, 2017).

More recently, North American bike-sharing start-ups have started to emerge on the continent. These companies, whose systems are also dockless, are backed by large venture capital investments. This is the case of San Mateo-based LimeBike, which raised US$12 million in Series A funding at the beginning of 2017, and San Francisco-based Spin, which secured US$8 million in investment. These two systems will be discussed further in this study, as they are currently involved in Seattle's bike-sharing scene (Alicea, 2017; Bueno, 2017; Kuntzman, 2017; Lloyd, 2017e & 2017f). These start-ups, like more established companies such as Social Bicycles, differentiate themselves from Asian bike-sharing start-ups by pointing to better quality bicycles and technology, as well as good bike redistribution to avoid saturated areas and piles of bicycles like in Shenzhen (Kuntzman, 2017).

In the face of this new phenomenon and the challenges it can bring, some cities have started to put restrictions on dockless bike-sharing systems. In August 2017, the City of Amsterdam announced its intention to ban dockless bike-sharing companies from the city. It explained that dockless shared bikes take up limited bike parking space at the

expense of local residents. Considering that locals usually have their own bikes, these companies are seen as intended for tourists, and occupy a lot space in a city saturated with bikes (O'Sullivan, 2017). In Shanghai, the city has asked bike-sharing companies to stop adding new bikes to their fleets, as it now has 1.5 million shared bikes on its territory. It also asked the companies to "aggressively relocate bikes parked and scattered carelessly across the city" (Horwitz, 2017). Other cities in China have taken similar actions regarding dockless systems. Guangzhou, Zhengzhou and Nanjing requested companies to stop adding bikes, while Nanjing asked companies to obtain a government licence for each of their bikes. The Ministry of Transportation in China also released its first country-wide framework to regulate bike-sharing, although it will let municipalities decide whether they will enforce the framework or regulate businesses otherwise (Horwitz, 2017).

2.2. Bike-sharing systems in North America

North America joined the bike-sharing game a few decades after Europe, with a boom in the 2000s. Prior to this, a few systems had launched, such as Portland's Yellow Bike Project in 1994. The project, similar to La Rochelle's *vélos jaunes* and Amsterdam's White Bikes, saw the non-profit United Community Action Network placing hundreds of free painted yellow bikes across the city. These were bicycles taken from junk piles and repaired by homeless or low-income youths. The program run for at least three years, but in the end, most of the bicycles ended up stolen or vandalized. In 2000, the program was taken over by the Community Cycling Centre, which used leftover bikes for their "Create a Commuter program" targeting low-income adults (Peacher, 2015; Rose, 2016; Ryan, 1994; Shaheen et al., 2012).

Between the mid-1990s and the mid-2000s, all North American deployed schemes were "White Bikes" first-generation or coin-deposit second-generation systems. It is only in 2007, with the arrival of the Tulsa Townies program, that third-generation IT-based systems started to be implemented on the continent. Since then, third- and fourth-generation schemes have proliferated on the continent, and most current systems today are part of these generations (Moennick, n.d.; Saint Francis Health System, n.d.; Shaheen et al., 2012).

Between 1994 and 2012, 40 bike-sharing schemes were launched and 11 programs were closed in the United States and Canada. These programs did not all grow at the same pace. Tulsa Townies did not increase its fleet in the first five years of operation, while Miami Beach's DecoBike (now called Citi Bike following its fusion with Downtown Miami's Citi Bike in March 2015), increased its fleet by 70% within the first year of operation (Meddin & DeMaio, 2017; NACTO, 2017b; Shaheen et al., 2012). At the end of

2016, 80% of the U.S. systems[2] that had been operational for a year or more had expanded their size since their launch (NACTO, 2017a). Other systems went big from the start, like New York City's Citi Bike, which launched in May 2013 with a fleet of 6,000 bikes at 332 stations. Two years later, the City started an expansion of the system with the aim of doubling the fleet to 12,000 bikes by the end of 2017 and adding stations in new areas. (Gastel & Tsnag, 2014; Kaufman & O'Connell, 2017; Motivate International, Inc., 2017a; Sadik-Khan & Solomonow, 2016). Montreal also started with a large fleet of 3,000 bikes distributed over 200 stations in May 2009. These numbers increased to 5,000 bikes over 300 stations within months, and in August 2017, the system had 6,250 bikes over 540 stations (Bérubé, 2017; BIXI Montréal, 2017; Cooper, 2009).

As of May 2017, there were seven bike-sharing systems in Canada (Meddin & DeMaio, 2017). The newest program is the Zagster bike-share in Peterborough, Ontario, which opened on April 19, 2017 with 15 bicycles over three different stations located in the downtown area and at Fleming College's Sutherland Campus (kawarthaNOW, 2017). Vancouver also adopted a bike-sharing scheme recently, officially launching its Mobi by Shaw Go in August 2016 with 670 bikes and 72 stations (Meddin & DeMaio, 2017). Once completed, the fully implemented system should have 1,500 bicycles and 150 stations (Vancouver Bike Share Inc, 2016).

In Mexico, as of May 2017, there were five bike-sharing schemes in operation, the newest being Puebla's BICIPUEBLA, which launched in January 2017. A sixth system, Huizi in Toluca, is currently not in operation. BIXI's bike provider, PBSC, is supplying Toluca's Huizi and Guadalajara's MIBICI's fleets. While Guadalajara's system, which opened in December 2014, now counts 2,116 bikes and 242 stations, Toluca's Huizi, launched in November 2015, is much smaller, with 350 bikes in 27 stations. The system was stopped in the spring of 2017, after the new local administration, which was not supportive of the previous government's project, stopped funding the system. As of August 2017, equipment has been stored and Huizi risks being permanently closed[3] (Abiudh García, 2017; Ávila, 2017; González, 2017; Meddin & DeMaio, 2017; Montaño, 2017; PBSC Solutions Urbaines, 2017). Mexico's biggest system is the popular ECOBICI, which launched in February 2010 with 84 stations and 1,200 bikes. Faced with high demand, the system expanded by 400% over the years to reach more than 6,000 bikes and 452 stations over 35 km^2 in 2016 (Ciudad de Mexico, n.d.a.; Meddin & DeMaio, 2017).

In the United States, according to NACTO (2017), there were 55 systems across the country at the end of 2016, compared to 4 in 2010. These numbers only include publicly-

[2] U.S. bike-sharing systems of more than 10 stations and 100 bikes (NACTO, 2017a)

[3] According to local stakeholders and newspapers' articles.

available systems with a minimum of 10 stations and 100 bikes (NACTO, 2017a). According to Meddin & DeMaio's Bike-sharing World Map, as of May 12, 2017, there were a total of 116 bike-sharing programs of all sizes and types within the United States. Two large systems were implemented in 2016: Portland's BIKETOWN, with its dockless smart bikes, and Metro Bike Share in Los Angeles. These new systems contributed to the 30% increase in the number of bikes nationwide. Indeed, the number of bikes has been steadily increasing, from 7,400 bikes in 2012, to 19,900 in 2013, and finally 42,000 at the end of 2016 (NACTO, 2017a). The number of smart bikes in the US has also increased significantly since the implementation of the first smart-bike program in 2014. In 2016, 31% of systems used smart-bike technology, but since most of the largest systems do not have smart bikes, only 13% of all bike-sharing bikes are smart bikes. That being said, most systems launched in 2016 use smart bikes, and the launch of programs such as Portland's BIKETOWN might represent a trend for future cycle hires in the country.

In 2010, 320,000 bike-share trips were taken in the United States. As a comparison, in 2016, 28 million trips were taken, of which 85% used one of the five largest programs in the country: Citi Bike in New York City, Capital Bikeshare in Greater Washington, D.C., Citi Bike in Miami, Divvy in Chicago, and Hubway in Greater Boston (NACTO, 2017b). Since these systems are known for their important station density, the results support the fact that an increased station density leads to a greater use of a bike-share system. The diagrams on the next page illustrate the constant increase in ridership, as well as the important impact of the largest systems on total ridership numbers. For instance, NACTO (2017a) reports an increase of 25% in the annual number of trips between 2015 and 2016.

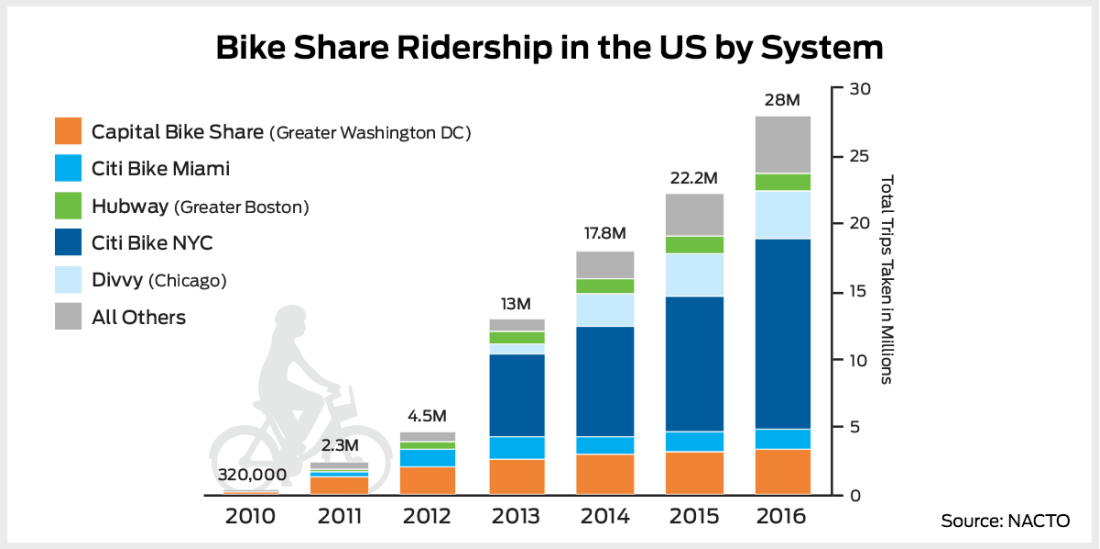

Figure 5[4]. This diagram shows the increase in bike-share ridership for publicly-available systems with a minimum of 10 stations and 100 bikes in the United States. It does not include small systems or private ones like ones on university campuses. Source: NACTO, 2017a.

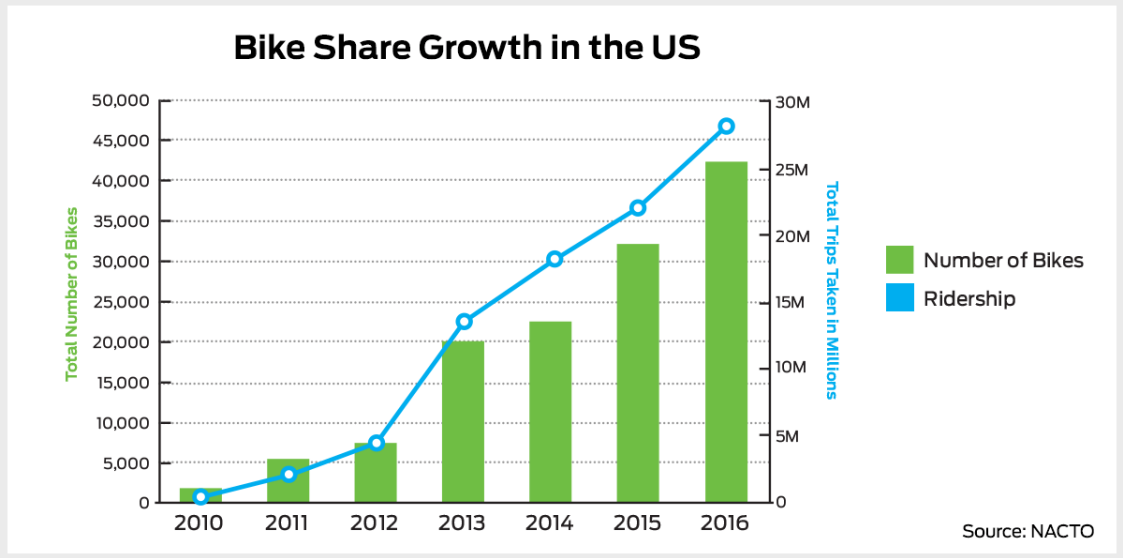

Figure 6[4]. Bike-share growth in the United States. Source: NACTO, 2017a.

[4] Figures 5 & 6 include data collected from NACTO regarding publicly-available systems with a minimum of 10 stations and 100 bikes in the United States. They include systems located in cities which are members of NACTO and others which are located in non-member cities.

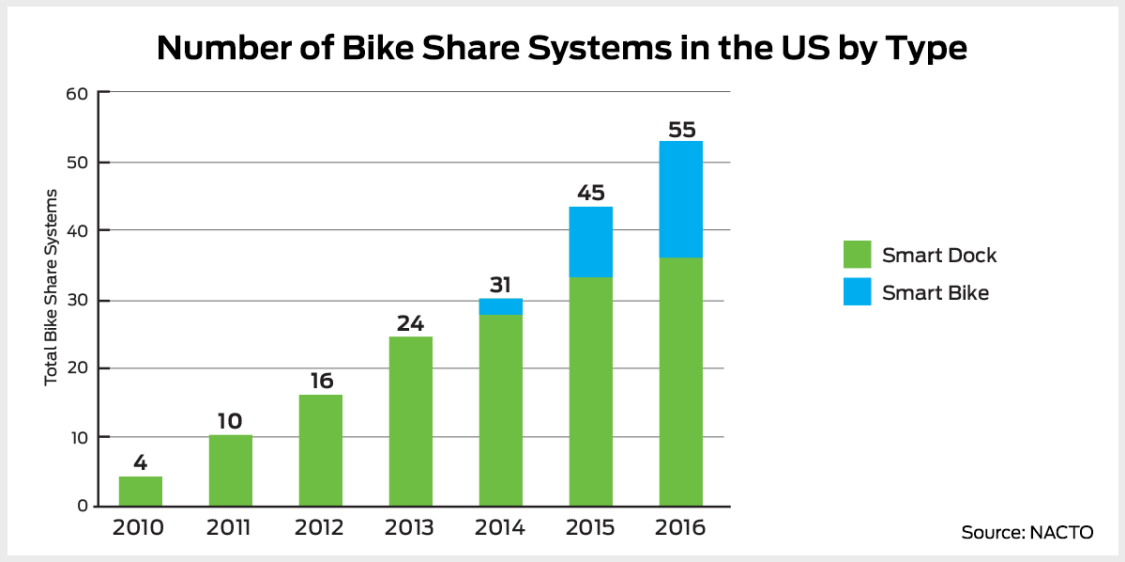

Figure 7[5]. Number of bike-sharing systems by type in the United States. Source: NACTO, 2017a.

Since 2010, 88 million trips have been taken with a bike-sharing system in the United States. Of the 28 million trips taken last year, most were of short duration, with an average of 12 minutes for trips by members. For casual, non-member users, the average duration is 25 minutes. As explained by the NACTO, "[this] indicates that most users use the systems to extend other transit options, and for point-to-point trips that may be too short for transit but too long to walk. This held true even with the new proliferation of smart-bike systems (as opposed to smart dock), which generally allow for pickup and return of bikes in a larger and more flexible area" (NACTO, 2017b). The data collected by the association also shows that 24% of bike-sharing systems in the country possess income-based subsidy programs. These programs ensure that cycle hires are accessible to all, independently of income or area. Rates in some of these programs can go as low as US$5 for an annual membership. In Chicago, the Divvy system is "serving almost two-thirds" of the residents, and a subsidy program, Divvy for Everyone, makes sure that citizens of all income levels can have access to it. The City also invested in building a network of segregated bike lanes. All these actions led to a 14% increase in the number of trips in 2016 compared to the previous year, with 3.5 million of trips recorded in Chicago last year (NACTO, 2017b).

In the US, there are many companies in charge of operating bike-sharing systems. Motivate owns the major share in terms of bike numbers, operating the largest systems

[5] Figure 7 includes data collected from NACTO regarding publicly-available systems with a minimum of 10 stations and 100 bikes in the United States. It does not include small systems or private ones like on university campuses. The figure includes systems located in cities which are members of NACTO and others which are located in non-member cities.

such as New York City's Citi Bike, Chicago's Divvy, San Francisco's Bay Area Bike Share, the Greater Washington, D.C.'s Capital Bikeshare, or Greater Boston's Hubway. However, in terms of the number of systems, Motivate operates only 20% of all systems. Many smaller schemes are operated independently by small organizations like non-profits. This is the case, for instance, of Nice Ride Minnesota, a non-profit in charge of the bike-sharing system for the Twin Cities of Minneapolis – Saint Paul. Other companies, such as Cyclehop, operate a fair amount of systems, but since they are smaller systems, they end up managing far fewer bikes than Motivate. Until 2015, Motivate's fleets were mostly provided by Montreal-based PBSC, it is therefore not surprising to see so many BIXI-like models of shared bikes in North America. It also contributed to the expansion of PBSC's model elsewhere in the world, such as in Australia with the Melbourne Bike Share, which was previously operated by Motivate (Motivate International, Inc., 2017a; Motivate, 2015; NACTO, 2017a; Nice Ride Minnesota, 2017a; PBSC Solutions Urbaines, 2017).

It is interesting to note that many of the big operators in the United States are also in charge of bike-sharing systems in Canada. For instance, Motivate ran Toronto Bike Share for a few years until recently, whereas CycleHop is currently in charge of Ottawa's VeloGO system since 2015, as well as Vancouver's Mobi by Shaw. However, although the two latter systems are run by the same operator, they use different equipment (Meddin & DeMaio, 2017). Vancouver's cycle hire bikes are provided by Smoove, a French company whose bikes are distributed in cities across the world, such as Montpellier, in France; Astana, in Kazakhstan; Moscow, in Russia; Helsinki, in Finland; as well as Marrakech, in Morocco. As for Ottawa's VeloGO (and SoBi Hamilton, in Canada), the bikes are produced by Social Bicycles, the same company that produces Portland's BIKETOWN's dockless bikes, as well as several other bike-sharing systems in the United States and elsewhere. Such systems include Buffalo's Reddy Bikeshare; Atlanta, Cleveland, Long Beach and Beverley Hills' Bike Share systems; Juice Bike Share in Orlando and Coast Bike Share in Tampa, Florida; as well as GRID Bike Share in Phoenix, Arizona (Meddin & DeMaio, 2017; Shaheen et al., 2012; Smoove, n.d.; Social Bicycles Inc., 2017).

What links the two bicycle provider companies is the fact that they both produce smart bicycles that can function without dock stations. Therefore, they participate in the spread of dockless bike-sharing systems, although their business model and approach are different from the Chinese start-ups mentioned earlier in this document (Smoove, n.d.; Social Bicycles Inc., 2017).

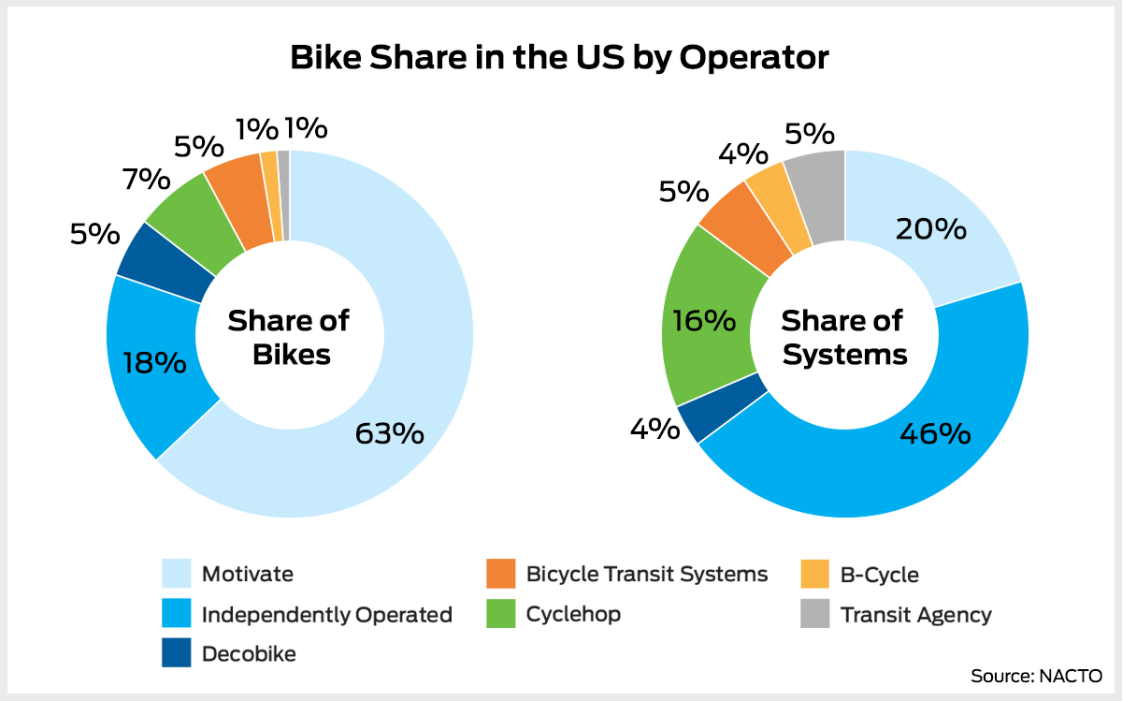

Figure 8[6]. This diagram shows the share of bikes and systems in the United States by operator. It includes only publicly-available systems with a minimum of 10 stations and 100 bikes in the United States. It does not include small systems or private ones like on university campuses. Source: NACTO, 2017a.

2.3. Business models, implementation and operation

In this section, we will look at the functioning of the different bike-sharing systems. We will address the various business and financial models while also discussing the implementation and operation processes.

2.3.1. The stakeholders

Beroud & Anaya (2012) describe four main types of stakeholders when it comes to bike-sharing systems: the promoter, the scheme operator, the equipment providers and public space users. The latter include both users of the schemes, as well as non-users who are affected by the initiatives through the increase in cycling practice and addition of furniture in the urban environment.

The promoter, also called the implementing agency or project developer, is the organization who conceived of the project and is the overall accountable manager of the program, although it might not oversee the operations. Very often, promoters are public bodies, such as local administrations usually in charge of public spaces or transportation

[6] Figure 8 includes data collected from NACTO on specific cities' systems. Some of these systems are located in cities which are members of NACTO, while others are located in non-member cities.

matters (Shaheen et al., 2012). For instance, a government might create an agency to be in charge of the implementation, contracting and launch of a bike-sharing system. If this agency does not act as an operator as well, then it will be responsible for contracting a company as an operator and putting into place performance criteria and service-level expectations to be followed by the operator. The promoter will also be the one deciding about the user fees and the revenue model. After the launch of the system, it will oversee the operator's activities to make sure that its performance is satisfactory. It acts with the government and public's best interests in mind, while also considering the operator's financial interests. In this regard, some experts recommend that the promoter be independent from the operator company in order to avoid any conflict of interest. The promoter is also in charge of deciding about future development or expansion of the system, as well as promotional activities. These last responsibilities can be taken on by the operator, depending on the system's situation and collected data (ITDP, n.d.; Shaheen et al., 2010).

Promoters can also be private agencies, like in the case of non-profit organizations, universities, or private companies. Those entities, although private, will often have to work closely with public administrations since bike-sharing systems rely most of the time on the use of public space and also aim at promoting inter-modal transportation. The backing of local transportation agencies is important for the success of most schemes (Beroud & Anaya, 2012; ITDP, n.d.).

Scheme operators are those running the system for the promoter. Their duties include maintaining the bicycles and stations, as well as doing bike redistribution between dock stations to balance the supply according to flows and demands. Operators are also in charge of customer service, information provision, payment processing, as well as all communication matters. They might oversee marketing and brand management as well, especially in the case where a promoter does not do community outreach and promotion (Beroud & Anaya, 2012; ITDP, n.d.).

As for equipment providers, they are the companies dealing with the production of bicycles, dock stations, kiosks, communication hardware, and software. They can receive their contracts through the promoters or the operators. (Beroud & Anaya, 2012; ITDP, n.d.).

2.3.2. Business models

The Institute for Transportation and Development Policy (n.d.) defines business models as the selection of "asset ownership and revenue flow between the government [or implementing agency] and the operator" with the goal of balancing service provision and the allocation of resources. Bike-sharing business models are usually similar to other

public transportation agencies' ones, and the difficulties in obtaining a return on investment greatly influence them. Three main components must be taken into consideration in the choice of a business model: the organizational structure, the asset ownership, and the contracting structure, including service levels. Systems can be completely public or private, but in most successful cases it involves a combination of both public and private entities (ITDP, n.d.).

Regarding asset ownership, there are three main types of contracting structure, although in every case the promoter or implementing agency is in charge of overseeing the system, dealing with the contracts and making sure that an appropriate level of service is offered:

- "Publicly owned and operated: The government owns the assets and provides the services.
- Publicly owned and privately operated: The government owns the assets but contracts a private entity to run the services.
- Privately owned and operated: The private entity owns the assets and provides the services" (ITDP, n.d.).

The organizational structure determines the relationship between the provider/ implementing agency, the operator, as well as other contractors or partners that might be involved in the "ownership, oversight, financing, operation, and management of the bike-share system" (Beroud & Anaya, 2012; ITDP, n.d.). The contracts and relationships often reflect different objectives and cultures within organizations (Beroud & Anaya, 2012). In some cases, the implementing agency simply owns the scheme, while a provider implements it and an operator runs it. An operator can be part of a government (like a public local authority), or it can be external and private, like in the case of for-profit or third-party operators like local businesses or non-profit organizations (Beroud & Anaya, 2012; DeMaio, 2009; ITDP, n.d.; Midgley, 2011; Shaheen et al., 2012; Shaheen et al., 2010). For instance, a bike-sharing program could be "operated in partnership with local businesses in exchange for a percentage of the profit." In such cases, the scheme could be a hybrid of different business models (Shaheen et al., 2012).

Here is a summary table of the different business models:

Promoter / Implementing agency	Provider	Operator	
Publicly-owned	Public provider	Public operator	Transportation agency
			Government/local authority
		Private operator (contractor)	
		Third-party operated	
	Private provider (contractor)	Public operator	Transportation agency
			Government/local authority
		Private operator (contractor)	
		Third-party operated	
	Advertising company	Advertising company	
Privately-owned with funding from the government (e.g. Non-profit or University)	Non-profit	Non-profit	
		Third-party operated	
	Contractor	Non Profit (e.g. Nice Ride Minnesota)	
		Contractor (e.g. University)	
Privately-owned	For profit	For profit	
	Contractor	For profit	
		Contractor (e.g. vendor operated[7])	

Table 2. Types of business models. Sources: Beroud & Anaya, 2012; DeMaio, 2009; ITDP, n.d.; Mátrai & Tóth, 2016; Midgley, 2011; Shaheen et al., 2012; Shaheen et al., 2010.

[7] Refers to the company manufacturing the equipment like the bike fleet and/or the software (Shaheen et al., 2012).

Publicly-owned systems operated by transportation agencies

Systems can be run by quasi-governmental or parastatal operators, like transportation and transit agencies. In these cases, the entities provide a range of transport services like buses, tramways, or car sharing. They have the advantage of having better connections with governmental entities and priorities (such as creating a better transit service), while also providing the government with more flexibility to adjust and link the system consistently with its policies and the other transportation services of which it is in charge. This allows the program to be modified more easily, since no contract renegotiation with an operator is necessary, making the system more responsive to market changes (Beroud & Anaya, 2012; DeMaio, 2009; ITDP, n.d.; Shaheen et al., 2012; Shaheen et al., 2010). It can benefit from part of the expertise of the agency in managing transportation services, but it can also suffer from the government's lack of expertise in managing cycling schemes specifically compared to private operators. Costs for the system can be diminished by relying on "existing assets such as customer service, maintenance personnel and depots," as long as the system is not big enough such that it requires its own departments and facilities (ITDP, n.d.). That said, such systems rely heavily on governments' vagaries, and they are especially prone to suffer from cuts or competition for public funds, or from changes in politics or governments (Midgley, 2011). Access and work with other transportation entities can prove hard since they can be perceived as competitors by the local agency. This type of models' functioning is also usually less cost-effective than in the case when operations are run from private sector entities. Moreover, having a local agency run the system puts more risk on the government (DeMaio, 2009; ITDP, n.d.).

This type of model can be seen in Avignon, where the Société de Transports en Commun de la Région d'Avignon (TCRA) is in charge of the Vélopop' system – which is produced by the French company Smoove. (Beroud & Anaya, 2012; Société de Transports en Commun de la Région d'Avignon, n.d.; Smoove, n.d.). In Germany and the Netherlands, national railway companies have provided bike-sharing systems which are linked to their train stations and other important destinations and transportation hubs, with the aim of improving their train users' travel options and experience. In the end, these systems benefit the whole population (Midgley, 2011). The system OV-fiets, in the Netherlands, is provided by NS, or Nederlandse Spoorwegen (*Dutch Railways* in English), the main passenger railway operator in the country. Bikes are accessible throughout the country, in locations such as train stations, bus stops and town centres. These bikes are slightly different from typical bike-sharing systems since their fares do not increase based on the duration of the trip, allowing people to borrow bikes for 24 hours and more. The fleet can also be found in both guarded and unguarded storage facilities, as well as in self-

service bike lockers or carousels, providing a wide range of possibilities in terms of operations. Regardless of these characteristics, the system is similar to traditional bike-sharing models as its main purpose is to provide an efficient and healthy option for travellers to reach their destinations (Nederlandse Spoorwegen, n.d.).

Publicly-owned systems operated and provided by a single private entity

It is very common for local authorities to give the contract for both the implementation and the operation of a system to a single entity (Beroud & Anaya, 2012; Midgley, 2011; Shaheen et al, 2012). In such cases, the operator is in charge of the whole project, making it easier in terms of management. This also reduces risks related to incompatibility between different elements, such as bike parts and their replacement. That said, while a private sector operator might be more efficient in running a cycling scheme than a government, its main goal is profitability, at least in the case of a for-profit organization. Thus, the enforcement of performance standards might prove hard in some instances. Moreover, there may be a clash between the operator's wish for optimizing revenues and the promoter's desire for a maximization of the utility of the system in order to reach as many citizens as possible. Covering as much area as possible and including low-revenue areas might not be beneficial to the operator, whose revenues could be higher if it ran the systems in areas generating more cycling trips. Therefore, promoters must clearly indicate the goals and obligations within the operator's contract and make sure that they are followed by the organization (Beroud & Anaya, 2012; DeMaio, 2009; ITDP, n.d.; Midgley, 2011; Shaheen et al., 2012; Shaheen et al., 2010).

Moreover, having one operator in charge of both providing the equipment and operating the system can be risky. Since the government is dependent on a single operator for the project, it can put the entire system in jeopardy if the operator struggles (ITDP, n.d.; Midgley, 2011; Shaheen et al., 2012). This happened in the case of BIXI's provider, Public Bike System Company – PBSC (*Société de Vélo en Libre-Service – SVLS*). The initial non-profit company ran the BIXI system in Montreal and provided the equipment. It also acted as the equipment provider for other systems around the world. Its international business branch was aimed at collecting additional revenues which, combined with user fees and revenues from advertising, would allow the Montreal system to function and expand. However, in 2014, the company was forced to declare bankruptcy by the City of Montreal, following years of financial struggle and stalled payments from client cities which were having software problems at their system's docking stations. The money made by the company through its international equipment company proved to be insufficient to pay for the operational costs of the Montreal system, leaving the company with a debt of CAN$46 million. The international business branch and the operator branch of the company were dissociated, with the international branch becoming PBSC Urban

Solutions, focusing only on the provision of equipment and technology. The operator part of the company was bought by the City of Montreal and converted into a new organization called BIXI Montréal. The saga led to major unplanned financial investments from the City of Montreal, while also creating instability in other cities where PBSC was supplying the equipment. For instance, PBSC was the supplier for Alta Bicycle Share Inc. (now Motivate), the operator for bike-sharing programs in New York City, Chicago, Boston and several other places. It also led to problems in other cities which had adopted the BIXI models, such as Toronto's bike-sharing system, which was originally called BIXI Toronto but was rebranded Bike Share Toronto following the dissolution of PBSC (Austen, 2015; Bloomberg News, 2014; Le Devoir, 2014; Magder, 2015; Spurr, 2016; Vailles, 2014).

New York City's system follows this type of business model, and its private operator is also the builder and provider of the system's latest equipment (this will be discussed in more detail further in this study) (Beroud & Anaya, 2012; Fermino, 2015; Fried, 2015; Motivate, 2015; Motivate, n.d.; Ziegler, 2015). Toronto Bike Share is another similar case. The system, which is a Toronto Parking Authority project, started as BIXI Toronto in 2011 and was then operated by the same company as BIXI Montreal until the latter went bankrupt in 2014 (Bike Share Toronto, n.d.; Le Devoir, 2014). It was later run by Motivate until April 2017, when its operations were entrusted to Shift Transit, a company created partly by the bike fleet provider PBSC Urban Solutions (Motivate, 2017; Shift Transit, 2017).

The case of Paris' Vélib' is different from the two previous examples, since the publicly-owned system is run by an advertising company, JCDecaux. In this scheme, the advertising company is in charge of providing the system's equipment as well as running it in exchange for free advertising space on street furniture such as bus shelters and other outdoor places like billboards, with the aim of generating revenues for the company. This model is seen in many cities in Europe and around the world. For instance, Lyon's Vélo'v and Seville's Sevici are both operated by JCDecaux (Ayuntamiento de Sevilla, n.d.; Beroud & Anaya, 2012; ITDP, n.d.; Mairie de Paris/SOMUPI, 2010a; Métropole de Lyon, n.d.a; Midgley, 2011; Shaheen et al., 2010). In Mexico City, SEDEMA, the City's Ministry of Environment, is the promoter or implementing agency for ECOBICI, but it contracts the advertisement company Clear Channel to operate the system (ITDP, n.d.). Clear Channel has been active in the field of bike-sharing systems' operations for more than 10 years, and in 2016, it was operating 15 systems and more than 20,000 bikes in eight different countries (Clear Channel México, 2016).

ITDP (n.d.) also presents the "BOT" model, short for "build, operate and transfer." In such cases, the operator implements and runs the system until the end of the contract,

and then transfers the ownership of the assets to the municipality or government. This type of contract can raise some issues, however. Profit-oriented operators may prefer to invest in inexpensive, lower-quality equipment that might not last much longer than the time of the agreement, in order to get a better return on investment. This can end up penalizing the government and citizens. It also highlights the need for clear contracts between promoters and operators (ITDP, n.d.).

Publicly-owned systems operated and provided by separate entities

An implementing agency or local government can also decide to issue separate contracts to different providers or operators for specific components of the system, such as software and hardware equipment, operations, advertising on the bikes and stations, as well as marketing and public relations. By doing so, it reduces risks and allows the promoter to deal with specialized companies with extensive expertise in each of the different service areas. That said, bundling contracts is usually simpler, and combining infrastructure provision with operation contracts can encourage the operator to provide good-quality infrastructure in order to reduce its maintenance costs (ITDP, n.d.; Shaheen et al., 2012). Providers of bike-sharing systems are often private contractors, but in some cases can also be public entities (Beroud & Anaya, 2012; Midgley, 2011; Shaheen et al, 2012).

In London, the Santander Cycles are provided by PBSC Urban Solutions, while the British company Serco is contracted by the transportation authority Transport for London to operate the system (PBSC Urban Solutions, 2017; Serco, n.d.). WeHo Pedals Bike Share, in California, is owned by the City of West Hollywood, while the system is operated by CycleHop and the equipment is provided by Social Bicycles, or SoBi (City of West Hollywood, n.d.). San Mateo's Bay Bikes system is another good example of a public-private partnership. The Californian program's equipment is also provided by SoBi, while the system is funded by the City and operated by Bikes Make Life Better, a local bike fleet operator (Midgley, 2011; San Mateo Bike Share, n.d.).

Publicly-owned systems provided and/or operated by a local authority (excluding a transportation agency)

In some cases, the local authority might decide to build and/or provide the scheme with the aim of running the operations itself through a transportation agency or via a contracted operator. Examples of such programs include La Rochelle's Yélo, in France, where the public body runs the scheme while the company FlexBike was contracted to provide the equipment and software (Beroud & Anaya, 2012; FlexBike, 2008). A few cases exist where public entities decided to develop their own equipment. For instance, in Vitoria-Gasteiz, Spain, the city council built its own software and created its bike fleet

through purchasing and receiving bicycle donations. It also provided parking in "suitably vandal-proof night storage facilities" (Beroud & Anaya, 2012). However, in this case, which is no longer active, the local authority did not operate the system, making it the opposite of systems like La Rochelle's (León, 2012). There are also schemes which are both implemented and operated by the local government, sometimes with support from NGOs like non-profits or a cycle promotion charity. Hangzhou, in China, is one example. It was created, developed, and is operated by a state-owned corporation, the Hangzhou Public Bicycle Transportation and Service Development Company (Beroud & Anaya, 2012; Press, 2011; Shaheen, Zhang, Martin & Guzman, 2011; Xiaofeng & Ran, 2016).

Privately-owned system run by non-profits organizations

Privately-owned systems can get funding from the government, such as in the case of some non-profits or universities, or they can rely on other sources of financing. The equipment can be provided by either the organization itself or a contractor. Some systems are run and owned by non-profits, like Nice Ride Minnesota and SoBi Hamilton (ITDP, n.d,; Shaheen et al., 2010; Social Bicycles Inc., n.d.a).

Right Bike, in Ottawa, Canada, is a non-profit organization which owns and operates a community-based, privately-owned bike-sharing program. Their service is made available through partnerships with local businesses and organizations, and the organization's partners include provincial and municipal governments, not-for-profit agencies, grassroots community movements, a local Business Improvement Area (BIA), and an insurance company (Causeway Work Centre, 2017; Shaheen et al., 2010).

Nice Ride is another good example of systems relying on partnerships and cooperation between several stakeholders. Indeed, while the non-profit Nice Ride Minnesota owns the program, the equipment was provided by PBSC Urban Solutions, and then assembled and installed by two local businesses, Freewheel Bike Shop and Sieco Construction. Other local professionals were also involved, and legal, design, marketing, accounting, public relations, and web development firms donated their time to realize the project. Expansion of the system was also supported by the National Park Service (Nice Ride Minnesota, 2017a).

Some non-profits are created expressly to run the program, whereas others exist already and add the operation of the bike-sharing system to their activities. This model has the benefit of prioritizing the well-being of the community over profits, and "places the liability on the non-profit which has limited funding and is less likely to be sued" (DeMaio, 2009). The goals of such systems are usually to cover the operational costs and to expand the system to the benefit of the users (Shareen et al., 2012; ITDP, n.d.). However, many non-profits are financially constrained and/or are dependent on government's

funding – such as public agencies' or councils' – which can put them in a vulnerable position (DeMaio, 2009; ITDP, n.d.). Some choose to make partnerships or have several funding sources to counterbalance that vulnerability (Shaheen et al., 2010). Non-profits can also have a "normally below-average business focus," which may lead to some unsustainable financial situations (ITDP, n.d.).

Reddy bikeshare, in Buffalo, is an example of a system which is run by an organization already operating many programs and projects. In this case, the system is run by the local non-profit Shared Mobility Inc. in partnership with the not-for-profit health plan Independent Health (Independent Health Association Inc., 2017; Reddy bikeshare, n.d.).

Privately-owned systems run by for-profit and/or equipment provider

Other programs can be owned and ran by a for-profit company or a vendor of equipment. In such systems, there is usually minimal or no government involvement, and the company keeps the revenues generated by the program (DeMaio, 2009; Shaheen et al., 2012; Shaheen et al., 2010). However, "financial constraints or suboptimal contractual conditions," as well as a lack of power to push for policy and planning changes can lead to a diminution of the system's efficiency (ITDP, n.d.). Such programs might be conceived or understood as an entrepreneurial activity, and because of their for-profit context, they might face challenges finding funding sources (DeMaio, 2009; Shaheen et al., 2012; Shaheen et al., 2010).

In 2013, T-Systems Hungary and Telekom launched a bike-sharing system for their employees. The system uses a Nextbike fleet and was implemented by Telekom and the Hungarian bicycle factory Csepel Zrt., which is also responsible for the management, logistics, and operations of the system. The company Telekom was also responsible for the development of a specific registration and fleet monitoring system, while the operator developed its own logistical system for maintenance and operations (Magyar Telekom Nyrt., 2017; nextbike GMBH, n.d.).

Privately-owned systems run by universities

This type of system allows an educational institution to increase its transportation options within and between its campuses independently from other systems in nearby areas. This provides more flexibility and control to the provider and operator, but has the inconvenience of benefitting only the university community and having potential compatibility issues with other cycle hire schemes in the area (DeMaio, 2009).

An example of such model is Share-a-Bull Bikes at the University of South Florida, whose system is managed and operated by the department of Campus Recreation within

USF's Student Affairs, while being funded through the niversity's Student Green Energy Fund. As for the fleet, it is provided by SoBi (Share-a-Bull Bikes, n.d.). Other universities have opted for a system operated by a private contractor, like Princeton University, which relies on the services and equipment of the company Zagster (Zagster Inc., 2017).

UBike, at the University of Virginia, is a good example of partnership and collaboration between different private, public, for-profit and non-profit entities. While the University of Virginia's Department of Parking and Transportation owns the system, the program was initially imagined by students at the university's School of Commerce, and the current project consists of a multi-year collaboration with the university's Office of the Architect. UBike is also partly funded by the Virginia Department of Transportation's Transportation Enhancement grants, and while Social Bicycles is the equipment provider, a local bike shop named the Blue Ridge Cyclery is maintaining the fleet (University of Virginia Parking and Transportation, n.d.).

The type of model to be chosen for a specific bike-sharing system depends greatly on several factors, such as area size and population density. For instance, advertising companies might prefer to run programs in larger cities where the potential for advertising revenues are greater (DeMaio, 2009). Another major factor is the type of stakeholder generating the idea (a government, an university, a non-profit, etc.) and the potential sources of funding (DeMaio, 2009). In 2012, out of 25 planned bike-sharing programs in North America, 21% were planning to be run by non-profits, 21% were planned to be publicly owned but run by a private operator, 29% would be run and owned by a public agency, 21% would be privately owned and run, and 8% would be operated by a bike-sharing equipment vendor (Shaheen et al., 2012).

2.3.3. Costs and financing systems

Bike-sharing systems generate important capital and operating costs. They can vary greatly based on the type and size of system chosen, the area covered by the system, and the population density, among other things (DeMaio, 2009). Capital costs include bike fleets, the docking station equipment and implementation, the "license or purchase or rental" of the operating software and system, the control centre, the depot for storage or maintenance of the equipment, member access cards, the purchase or rental of distribution and maintenance vehicles, as well as the system's installation on the ground (DeMaio, 2009; ITDP, n.d.; Midgley, 2011). They also include working capital and costs of running the system before it starts generating revenues, which include "pre-launch staffing, installation, marketing, website creation and launch expenses" (ITDP, n.d.). According to the New York City's Department of City Planning (2009), the capital cost per bicycle usually varies between US$3,000 (approximate cost per BIXI bike in Montreal) and

US$4,500 (cost per Vélo'v unit in Lyon). Other studies looking at 10 different bike-sharing operators' numbers showed that bikes' costs range between US$750 and $7,000, with an average cost of US$1,800. In many cases, docking stations' prices include bicycles. ITDP's bike-share planning guide (n.d.) also mentions the capital cost per bike for several systems. According to the guide, most of the pre-2014 large North-American systems have a capital cost per bike situated above US$4,000, while systems in other parts of the world tend to be less expensive, with Rio de Janeiro's capital cost per bike being US$1,810 for instance. The cost to replace a bike also varies widely, from US$69 for Guangzhou Public Bicycles, to US$1,270 for Montreal's BIXI system and US$1,435 for London's Santander Cycles. Bikes with GPS and satellite-operated unlocking systems can also be very expensive to replace (ITDP, n.d.). Vendors' complete kits usually include kiosks, bicycles, dock stations, map frames, customer keys, spare parts, supplies and shipping (Gleason & Miskimins, 2012; Shaheen et al., 2012). A station price can range from US$26,064 to $58,000, with some studies showing an average of US$39,550 (Toole Design Group & the Pedestrian Bicycle Information Center, 2012). Larger stations are also more economical than smaller ones. As an example, one operator estimated the cost of a small station of four bikes and seven docks at $26,064, or US$6,516 per bike. The cost for a station of 13 bikes and 19 docks, on the other hand, was US$52,275, or US$2,751 per bike (Shaheen et al., 2012).

Operating costs include "maintenance, distribution [including fuel for the vehicles], staff, insurance [(for anti-theft, accidents or vandalism)], office space, storage facilities, website hosting and maintenance, electricity charges for the docking stations, membership cards[,] warehouse/storage fees [and insurance]," Internet connectivity for stations, administrative costs and potentially debt service (if a loan is taken) (DeMaio, 2009; ITDP, n.d.; Midgley, 2011). Costs can vary greatly based on the size, business and financial model, type of system, intensity of ridership, profit margin of the operator, contracted service levels and specific tasks mandated (ITDP' n.d.). Based on NYC's Department of City Planning's 2009 bike-sharing study, those fees are usually located between US$1,200 and US$1,700 per bike per year. The relocation of a mobile station, for instance, can cost US$1,000 to $1,500, with other studies finding an average cost of US$4,000. In terms of average operating cost per trip, it varies greatly as well, ranging from US$0.86 in Barcelona to US$1.27 in Montreal, US$3.09 in Boston and US$4.80 in London, UK (ITDP, n.d.). In terms of annual operating costs, they are usually located between US$12,000 and US$28,000 for a station of 11 to 19 docks (Gleason & Miskimins, 2012; Shaheen et al., 2012; Toole Design Group & the Pedestrian Bicycle Information Center, 2012).

Systems rely on several financing methods to cover their costs and break even, with some even generating profits. The simplest way to collect money is through user fees, such as subscription and rental – or usage – fees. Subscription fees relate to the required registration of users for a specific time period, like a week, a day or a month, while usage fees are linked to the specific amount of time that the bike is in use by the user. Most systems propose low membership and usage prices in order to attract people, and the first thirty minutes are usually not charged to the users besides the basic registration fee. After these 30 minutes, prices increase continually to encourage people to make short trips and make bicycles available to other users (ITDP, n.d.; Midgley, 2011; Pignon sur rue, 2006; Ricci, 2015). In most systems, the software works in a way that prevents users from checking out a bicycle right after returning one, in order to prevent them from switching bicycles every 30 minutes to avoid a surcharge for a longer ride. A lag time of a few minutes is often required between rides (Flegenheimer, 2012).

These methods have proven adequate for many systems. For instance, more than €30 million were collected via membership and user fees during Paris' Vélib's first year of activity. The company JCDecaux, which underwrites the system's costs in exchange for advertisement space, payed the program's start-up costs of around US$115 million, and is in charge of operating and maintaining the system. Revenues generated by the system are collected by the City, and the operator also pays the City royalties of US$4.3 million per year. In exchange, JCDecaux obtained exclusive control over 1,628 billboards owned by the City. Revenues generated from these billboards will allow the company to pay for the costs associated with the system and still make substantial profits (Anderson, 2007; Erlanger, 2008; ITDP, n.d.; Midgley, 2011; Pignon sur rue, 2006; Ricci, 2015). The case of Washington, D.C.'s system is another relevant example of a successful fee structure. The system was built using federal money, but its operating costs are entirely covered through user fees. Its financial model is so efficient that in 2016, it was the "only transit system in the country to break even" (Blue, 2016).

Ricci (2015) notes that it is important for bike-sharing providers and operators to not only attract annual members, whose subscriptions provide a stable revenue stream, but also to get high numbers of occasional/casual users as they are instrumental in the long-term success and financial viability of a system. This could allow systems to generate more revenue, thus diminishing the need for public subsidies. To do so, systems must also be customized for this clientele. The author selected four key factors that may impact the financial viability and profitability of a system: the location of stations, for instance near tourist attractions, mixed-used areas and transit nodes and stops; the "ability to retain registered members, e.g., annual members; providing a range of discounts; and, finally, the ability to find new revenue sources" (ITDP, n.d.; Ricci, 2015).

Many systems keep user and membership fees low. For instance, Washington's Capital Bikeshare's annual membership is US$85, while a 24-hour pass is US$8 and single trips are priced at US$2, with the first 30 minutes at no cost. The program also has 3-day passes, 30-day memberships, and other special programs such as corporate memberships, bulk pass sales, and financial assistance programs (Motivate International Inc., 2017b). This large range of options increases the flexibility for users and make the scheme more attractive. Vélib's prices are also affordable and flexible. Typical annual memberships are either €29 or €39, depending on whether the user chooses to have the first 30 or 45 minutes of each ride at no extra cost. The first extra half-hour is charged at €1, the second one, €2, and the following ones €4. Short-term tickets are also affordable, with daily passes costing €1.70, and 7-day passes €8 (ITDP, n.d.; Mairie de Paris/SOMUPI, 2010b). Though these fees are very low and do no generate much revenue from an individual perspective, high ridership levels can generate large sums of money. Many systems in Europe have adopted similar competitive prices, such as Brussels' Villo! and Lyon's Vélo'v. Villo! offers annual membership cards for €33.60, weekly tickets for €7.90, and daily tickets for €1.60. The system charges less per extra half-hour, the first one being €0.50, the second one €1, and the following €2 (JCDecaux Street Furniture Belgium, n.d.). Vélo'v offers even more competitive prices. Its annual membership costs €25 or €15 for people under 26 years old. A 24-h ticket costs €1.50 and a weekly ticket, €5. The city also offers, for €3, a 3-day ticket with an extended free use period of 60 minutes instead of the typical 30 minutes. This option allows the system to target other types of users than the regular commuters, such as tourists, and people wishing to do either longer or non-commuter trips for short periods of time. Prices per extra half-hour are lower for annual members, a method used to encourage residents to choose the annual offer instead of weekly or daily passes. Thus, the first extra half-hour is €0.75 for annual members, versus 1€ for other users, and the following periods of 30 minutes are charged €1.50 instead of €2. The program also offers a corporate option for businesses, institutions, and organizations, with the aim of attracting more employees to commute by bike (Métropole de Lyon, n.d.c.).

The low fees associated with these systems make them accessible to more people of different incomes. In some cases, prices are even lower than those offered for similar systems in metropolises in developing countries. For instance, Mexico City's ECOBICI charges 416 Mexican pesos (CAN$30.15[8]) for an annual membership, which is only slightly lower than the previous systems' prices. However, this amount represents a bigger portion of a local resident's salary compared to the financial burden of similar passes on a European's budget. Seven-day passes are MXN$312 (CAN$22.60), 3-day tickets, MXN$188 (CAN$13.62), and daily passes MXN$94 (CAN$6,81), which are all

[8] As of May 31st, 2017.

higher amounts than those collected for similar passes in the European systems mentioned previously. This demonstrates a commitment on the part of these European cities to make their systems available to everyone, including people with low salaries. It is interesting to note that ECOBICI maintains the first 45 minutes of use free of charge, instead of the usual half-hour (Ciudad de Mexico, n.d.b).

In some cities, fees are much higher than those mentioned above, and they contribute to a sizeable part of the system's revenues. For instance, New York City's Citi Bike offers daily passes for US$12, 3-day passes for US$24, and annual membership (which includes the first 45 minutes of each trip at no cost) for US$163. As for London's Santander Cycles, in the UK, the system charges £2 (CAN$3.48[9]) for a 24-hour pass, and £90 (CAN$156.47) for a yearly membership. Most of these prices are considerably higher than those found in many cities in Europe and North America. However, the success of both systems seems to show that pricing was not a significant issue in these cities, which might be partly linked to the high costs of living in New York City and London (Motivate International, Inc., 2017c; Transport for London, n.d.).

Besides user fees, there is a wide variety of methods on which bike-sharing schemes can rely in order to break even. Subsidizing is very common, be it through governmental subsidies or grants. Sponsorship contracts, parking revenues, tax revenues or advertising revenues or contracts can also be used to fund a system (ITDP, n.d.; Midgley, 2011; Ricci, 2015). Funding for capital costs, operational costs or both usually rely on a mix of funding sources, such as advertising, grants, sponsorships, private investment, health-care settlement funds, as well as government funds. Operators usually rely on a combination of user fees, advertising, and sponsorships to cover the operational costs. The advertising model is more prevalent in Europe, while the sponsorship model is more common in North America. The sponsorship model differs from the advertising model in that the owner or operator of the scheme sells advertising, for instance on bikes, instead of having an advertising company running the scheme (Beroud & Anaya, 2012; ITDP, n.d.; Ricci, 2015; Shaheen et al., 2012). ITDP (n.d.) recommends that promoters draw very clear contracts with system operators in order to avoid misunderstandings and errors regarding the collection of generated revenues.

In 2012, 95% of North American bike-sharing systems were funded through user fees, 89% relied on sponsorships, and 68% used advertising to fund their system. Grants and loans represented respectively 26% and 16% of funding. Thirty-two percent of North American bike-sharing systems relied on local government funding, 26% used provincial or state government's money, 26% relied on the federal government, and 16% received

[9] As of May 31st, 2017.

private funding. It is not rare to see schemes receiving funding from more than one level of government. Forty-two percent of the analysed schemes had four sources of funding, while 26% had three and 32% had five (Shaheen et al., 2012).

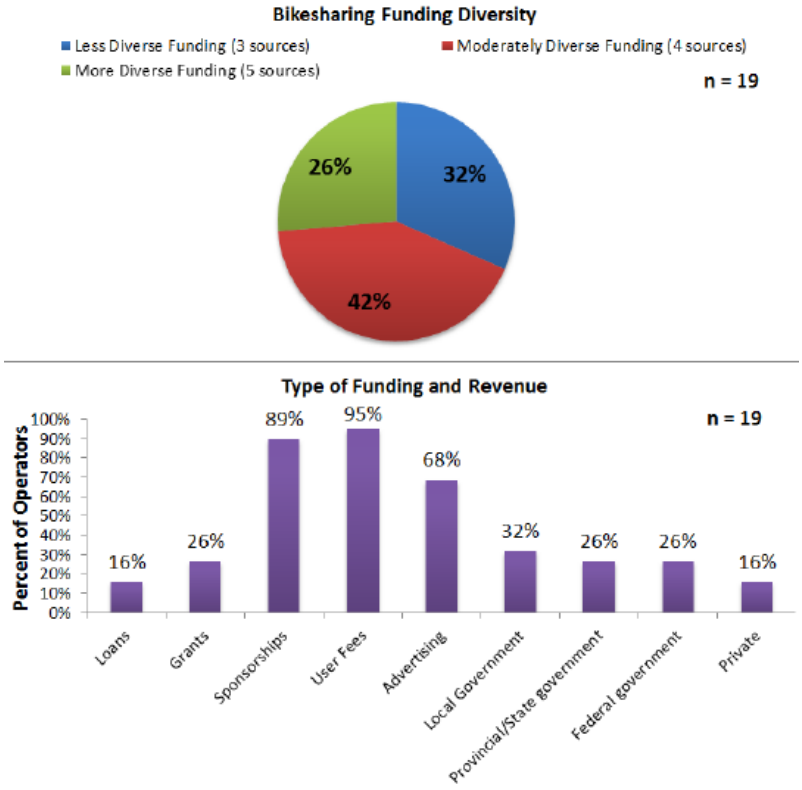

Figure 9. Bike-sharing funding in North America.
Source: Shaheen, Cohen & Martin, 2012.

Public-private partnerships with outdoor advertising companies can be seen in many places around the world (such as ECOBICI in Mexico City), especially in Europe (Lyon's Vélo'v, Paris' Vélib', Brussels' Villo!, Seville's Sevici for instance). A few companies are major players in the bike-sharing world, like JCDecaux and Clear Channel. This financial model presents a significant advantage for the municipality since it involves "little or no direct public funding," so "the system can appear to have little to no cost to the taxpayers" (Midgley, 2011), since the advertising company is funding the project and covering all capital and operating costs in exchange for advertising space in the public realm (DeMaio, 2009; ITDP, n.d.; Shaheen et al., 2010; Shaheen et al., 2012). The company can display "revenue-generating advertisements" in these spaces, which allow them to reimburse and pass the costs associated to implementing, operating, and maintaining the bike-sharing system (DeMaio, 2009; ITDP, n.d.; Shaheen et al., 2012). However, by providing space on street furniture like bus shelters, kiosks and billboards to the advertising company, the City deprives itself of advertising revenues. For instance,

JCDecaux's annual advertising revenues were estimated in the 2000s at €60 million (US$80 million) for Paris' Vélib' and €27.8 million (US$36.5 million) (ITDP, n.d.). There may be backlash from the population as a result of the increased outdoor advertising. In some cases, revenues generated by the system go to the local government, in which case the company might have less incentive to provide quality service since it does not gain revenues in return (DeMaio, 2009). Despite these considerations, the model seems to be working well, considering the success of many bike-share schemes funded and operated by advertising companies – Paris, Lyon, Mexico City, to name just a few (Ayuntamiento de Sevilla, n.d.; Beroud & Anaya, 2012; DeMaio, 2009; ITDP, n.d.; Mairie de Paris/SOMUPI, 2010a; Métropole de Lyon, n.d.a; Midgley, 2011: Shaheen et al., 2012). There are also cases where advertising occurs on the bike-sharing system equipment only, like stations or bikes (ITDP, n.d.).

User fees are also important components in systems following the advertising model. For instance, in Lyon's Vélo'v, the promoter, the Métropole de Lyon, provides a subsidy for part of the system, and the advertising company JCDecaux operates the system jointly with the local government. User fees are collected by the City. Revenues generated from these are not only used to reimburse the subsidy, but they can also be used by the City for other programs, since they do not need to pay capital or operational costs. As a result, the system is financially successful: the City receives revenue generated by user fees, and the costs associated with the implementation and running of Vélo'v are paid by the advertising space used by JCDecaux. The initial contract between the City and the enterprise stipulated that for 13 years, the company would provide and run 4,000 bikes in exchange for the urban furniture advertising market in the city. Money generated by the advertising space allows the company to make profits, which makes for a win-win situation for both the City and the company. In the case of Paris, though the City does not collect the user fees, it does not subsidize the system either. All costs are the responsibility of JCDecaux (Midgley, 2011; Pignon sur rue, 2006; Vogel et al., 2014).

Governmental grants or subsidies are a source of funding for several systems around the world. For instance, BIXI in Montreal survives through grants from the City of Montreal. Madrid's BiciMAD receives subsidies, while its user fees go to the operator, leading to some loss of revenue for the government (Le Devoir, 2014; Mátrai & Tóth, 2016). In Germany and the Netherlands, national railway companies have implemented cycle hires and use revenues from their other transportation activities to partly fund their bike-sharing programs. Municipal public transport agencies and parking agencies also fund several bike-sharing programs, and their revenues are often used to cover operating costs. For instance, the funding for Barcelona's system, Bicing, comes partly from on-street parking revenues, "a clear cross-subsidy from motorists to cyclists" (Midgley, 2011;

Shaheen et al., 2010; Spoorwegen, n.d.). Some non-profit models rely in part on government's funding, like the Nice Ride program run by Nice Ride Minnesota, whose funding comes from the Federal Highway Administration and other sponsors like Blue Cross and Blue Shield of Minnesota (Nice Ride Minnesota. 2017a). While this specific program benefits from several sources of funding, others rely heavily on government funding, which makes them vulnerable to changes in policies and programs (DeMaio, 2009). It is thus not infrequent to see non-profits opt for many funding sources such as partnerships or sponsorships with private entities – like health plans, banks and insurance companies, bank loans, or local funding through organizations as in the case of Right Bike mentioned earlier (Causeway Work Centre, 2017; Shaheen et al., 2012; Shaheen et al., 2010). SoBi Hamilton, or Hamilton Bike Share, is a good example of such a situation. The operation of the system, which is run by a non-profit organization of the same name, is not funded through government taxes. Instead, it is funded through "membership fees, sponsorship funding, and in-kind services provided by [its] community partners." The project includes cooperation between different levels of governments, local professionals, non-profits, and businesses. Profits made from its operations are used to increase and enhance the system and service. The system also chooses to rely on Social Bicycles' smart bikes, a less expensive option (Social Bicycles, n.d.).

Large grant funding programs are less common, but exist nonetheless. For instance, the European Commission's CIVITAS program has being instrumental in the development and implementation of bike-sharing cities through its provision of funding. Another example is the provision by the Spanish Institute for Diversification and Saving of Energy (*Instituto para la Diversificación y Ahorro de la Energía* – IDEA) of €2.5 million for the implementation of 56 bike-sharing schemes in 2008 (Midgley, 2011).

One of the most common types of financing model, especially in North America, is sponsorship (Shaheen et al., 2012). It can complement revenues from user and members' fees, as well as government funding (Shaheen et al., 2010). In such cases, the system's image and brand is linked to a sponsor and often includes naming rights (ITDP, n.d.). This is the case, for instance of San Francisco's Bay Area Bike Share, which officially became Ford GoBike on June 28, 2017, following a partnership with Ford. This deal will allow the system to be expanded from 700 bicycles to 7,000, without the involvement of public money (Motivate International Inc., 2016b).

One risk of this financial model is the association with a private entity whose reputation might change over time, which could impact the system's own image. A risk mitigation plan can be prepared to avoid such situations (ITDP, n.d.). Philadelphia's Indego system, which is owned by the City of Philadelphia but is operated by the Philadelphia-based bike fleet operator Bicycle Transit Systems, has major sponsors. The

system, whose bikes are provided by the company BCycle, is sponsored by the Independent Blue Cross, an insurance company, and has a partnership with the bank Capital One (Bicycle Transit Systems, n.d.; Indego, 2017). This type of partnership and sponsorship is common in North America and elsewhere. For instance, some of the largest bike-sharing systems in the world rely partly on sponsorship from banks to finance their programs. This is the case of the London's Santander Cycles and New York City's Citi Bike (Beroud & Anaya, 2012). While the former is operated by a transportation agency, the latter is run by a bike-sharing operator, which demonstrates that this type of financial model can be used in several business models (Shaheen et al., 2010).

Sponsorships and partnerships can also be included with other types of entities, such as health plans. For instance, the Capital Region in the state of New York will soon have its CDPHP *Cycle!* program, which plans to launch in the summer of 2017 through a partnership between the Capital District Transportation Authority (CDTA) and Capital District Physicians' Health Plan, Inc (CDPHP) (Social Bicycles Inc., 2017).

Smaller systems may choose a financial or business model that allows them to get a bike-sharing scheme at a lower cost. For instance, dockless bike-sharing systems are usually less expensive than those with dock stations, as the bikes' costs are lower and there are no expenses linked to stations. This makes these programs more affordable and therefore more accessible to smaller municipalities (CycleHop, LLC, n.d.).

CHAPTER 3:
LITERATURE REVIEW

The previous chapter focused on the historical and operational sides of bike-sharing systems and provided an overview of the types, financing, and organizational models that can be encountered around the world. In this chapter, we focus on the use and repercussions of bike-sharing systems, in order to get a better understanding of the roles they can play in cities. The first section assesses the different types of riders attracted by bike-sharing schemes, as well as their types of trips, according to the literature. Then, the expected goals of systems will be described, followed by the schemes' actual impacts and benefits. Finally, the last section will look at the difficulties, challenges, and opportunities faced by systems around the world, and how they have tried to overcome some of these barriers, successfully or unsuccessfully.

3.1. Types of users and usage

Who uses bike-sharing systems? Several studies have looked at the question and concluded that there are specific socio-economic and demographic types of users who are attracted to bike-sharing systems.

The most common profile of bike-sharing users is white males, employed, and younger than the average population in areas covered by systems. They are also more affluent and educated, and there is a higher chance that they were cycling before the cycle schemes were implemented. For instance, in Dublin, Ireland, 78% of Dublinbikes' users are men, and 58.8% are aged 25-36. Users usually have higher incomes than the population average, with 57.3% of users earning €40,000 or more per year (Murphy & Usher, 2015; Ricci, 2015). Other studies have confirmed similar situations in other contexts. In London, for instance, women represent less than 20% of the total trips made with the Santander Cycles (Goodman & Cheshire, 2014). A 2013 study using an online survey for members of five North American systems showed that in Montreal, Toronto, Salt Lake City, Minneapolis-Saint Paul and Mexico City, Caucasian users aged 25-34 were dominant (Shaheen et al., 2014). In Washington, D.C., 81% of Capital Bikeshare members are white, and most have an above-average income, a situation that is similar for Boston's Hubway system (Blue, 2016).

Studies show that cycling in London is done predominantly by affluent white men. For women, Black and Asian people, the lack of visibility of female cyclists or cyclists of colour makes people see cycling less as a transportation option. The archetypes associated with cycling might also deter people from biking. For instance, in London, cycling is often associated with an effective, autonomous, and protective "assertive" style which might appeal to professional white men and women. At the same time, this aesthetic and

symbolism might not resonate as well for other classes, genders, and ethnic communities (Steinbach et al., 2011).

In general, the average user profile shows that "bike sharing reproduces unequal patterns of participation associated more in general with cycling, reflecting gender, class and ethnic differences in cycling practices found in countries with low cycling levels" (Ricci, 2015; Steinbach et al., 2011). However, people living in low-income areas use bike-sharing when it is accessible in their area. A study has even shown that registered users in poorer areas of London have higher trip rates when taking into account that these areas are less likely to be near a station. That being said, women and residents from poorer areas are still under-represented (Ricci, 2015).

A few reasons can explain these findings. One main factor is the geographical coverage of bike-sharing systems, which can greatly influence the socio-economic profile of its users. Systems are unevenly spatially distributed and are usually concentrated in socio-economically active neighbourhoods and areas, such as universities and downtowns, as well as near inter-modal transportation hubs such as metro stations. Therefore, users represent demographics of people living or working in these areas, such as students, professionals, and one-person households (Ricci, 2015). Blue (2016) explains this phenomenon in the case of Denver, Colorado. There, 90% of the bike-sharing system's users were Caucasian according to initial research following the system's launch in 2012. When a city councillor openly complained about the lack of stations in his West Denver district, which is largely Latino, he was told that due to funding constraints, stations were implemented where they could generate the highest revenues, which excluded his district. People of colour and low-income populations often have a more limited access to cycling due to the lack of biking infrastructure and safety conditions on their streets (Blue, 2016). Moreover, systems usually require the use of debit or credit cards, or a several-hundred-dollar hold on a potential user's bank account. This can be a major barrier for people from lower-income backgrounds, especially considering that one in twelve households in the U.S. are unbanked (Blue, 2016; Goodman & Chesire, 2014; Murphy & Usher, 2015).

In order to solve this inequity problem, some cities have tried to attract people from low-income backgrounds. For instance, Lyon's Vélo'v system's annual membership cost only €15 in 2011, and transit integration from a spatial perspective and through pricing policies have made the system more affordable and accessible (Ricci, 2015). In March 2014, Hubway's "Prescribe-a-Bike" program was launched in Boston. Through this program, low-income residents can get annual memberships for only US$5. These subsidized memberships are offered by Boston Bikes and the Boston Public Health Commission. Participants receive free helmets, unlimited one-hour trips on the bikes, and

a Bicycle Benefits sticker (Carlson, 2015; City of Boston, n.d.). A partnership with the Boston Medical Centre also allowed doctors to write prescriptions for the bike-sharing system to low-income residents (Malamut, 2014). In a more general way, the American Internal Revenue Service, through the Bicycle Commuter Act, added a bicycle commuter reimbursement to its list of qualified transportation, tax-free commuter benefits, which involved for instance a reimbursement of up to US$115 per month for public transport or US$210 per month for parking. Users can now receive up to US$20 per month for expenses linked to bike commuting. The reimbursement is a fringe benefit paid by the employer (Carlson, 2015; Center for Urban Transportation Research at the University of South Florida, 2017; League of American Wheelmen, Inc., 2015).

Community groups and local organizations have also worked to make bike-sharing more accessible to marginalized and vulnerable populations, and they have used it as a way to solve other issues in low-income communities (NACTO, 2017a). This happened in the neighbourhood of Bedford-Stuyvesant, in New York City. Local organizations partnered with the City of New York and Citi Bike to promote bike-sharing as a way to improve health conditions in the majority-Black community (Katinas, 2017; NACTO, 2017a; Rodriguez, 2017; Snow, 2017).

People with physical disabilities are also often excluded from bike-sharing systems. This is why BIKETOWN in Portland will launch, in fall 2017, a public adaptive bike-sharing program for people with disabilities called Adaptive BIKETOWN. It will be the first city-sponsored bike-share program in the United States to target persons with disabilities. When the initial BIKETOWN system was launched in 2016, disability rights advocates reminded the City that it should work towards providing bike-sharing for everyone, including people with disabilities. The City addressed the issue, and one year later the new program was inaugurated, with financial support from the Portland Bureau of Transportation, which will own the system, and Nike. It will act as a bike rental service, with private bike rental shops located near multi-use trails acting as partners for the program. There will be no stations like in the BIKETOWN program, as the purpose here is not so much to serve commuters but recreational cyclists. Multi-person cycles (like tandems), hand cycles, and foot-powered bikes will be available at affordable prices (US$5 per hour or US$12 for 3 hours) and citizens will be able to rent them through their transit pass. The fees will only be available for people who qualify for a TriMet Honored Citizens Pass, such as people with disabilities, seniors, and Medicare recipients. Other services will be provided such as helmets, mobility device storage, and crate storage for service animals. People without the TriMet Honored Citizens Pass will have the right to rent the bikes as well, but higher rates will apply (Dovey, 2017; Hintze, 2017; Metcalfe, 2017; Portland Bureau of Transportation, n.d.; Schmitt, 2017a).

Other facts and data on bike-sharing riders have been collected through studies and surveys. Regarding helmets, a 2015 study concluded that out of 4,919 cyclists observed on a Citi Bike, only 11.1% were wearing helmets, showing that the program's strategy of endorsing helmet use through education is not successful (Basch et al., 2015). These numbers coincide with other studies and data, which show that bike-sharing riders are less likely to wear helmets than other urban cyclists. For instance, some researchers found that around 20% of cycling scheme riders in Boston and Washington wear a helmet, while this number falls to 15% for New York City (Basch et al., 2015; Basch et al., 2014a & 2014b; Bonyum et al., 2012; Fischler et al., 2012; Grenier et al., 2013; Kraemer, Roffenbender, & Anderko, 2012). In Australia, a study undertaken amongst the population of Melbourne found that 61% of the respondents, when asked what was the main barrier to widespread use of the local bike-share, answered helmet issues (there is a mandatory helmet law enforced in Australia). This supports the argument that having to wear a helmet can be a deterrent to using a bike-sharing system (Fishman, Washington & Haworth, 2012).

In her book *Streetfight*, Janette Sadik-Khan defines young urban generations, whose use of bike-sharing systems is important. She describes a "zip" generation made of young people who are not interested in owning a car. She explains that fewer young adults get their driver licences today; while 87% of nineteen-year-old Americans had one in 1983, only 70% did in 2010. Instead, young Americans drive less and take much more transit than in the past. She explains that "[m]any younger Americans, particularly those in cities, see driving as a frustrating, time-wasting chore, and are stressed out by traffic incivility, cost, and the difficulty of finding a parking space. Car ownership is a huge up-front financial commitment…. [cars] aren't worth the 24/7/365 commitment, expense and hassle of car ownership" (Sadik-Khan & Solomonow, 2016). Considering that some studies in cities like Montreal have shown that bike-sharing systems mostly attract people who use public or active modes of transportation, this makes young adults a good target audience for bike-sharing schemes (Guénette & Doucet, 2017; Société Radio-Canada, 2010).

In terms of usage, there are wide variations based on several factors. Popular schemes, such as Washington, D.C.'s Capital Bikeshare and London's Santander Cycles, can expect each bike to be used between 3 to 8 times per day. Other less successful schemes have a use rate of less than 0.3-0.4 trip per day per bike, like schemes in Australia (Ricci, 2015). Adding new usage options can help to increase a system's use. For instance, in London, the addition of options for casual riders in December 2010 brought an increase in the use of the system while also changing the system's trip patterns. Commuting trips increased, and so did use on the weekends. Before the changes, only annual members

benefited from the system. This revealed that annual members and casual riders do not have the same preferences and patterns of use (Ricci, 2015).

Bike-sharing systems are mostly used for utilitarian purposes, and especially work-related activities, which explains why one can see an increase in their use at peak hours. Outside of peak hours, the types of trips are more varied, with more leisure-related trips and non-work utilitarian trips (Ricci, 2015; Shaheen et al., 2012). Bike-sharing uses and ride purposes also vary greatly based on gender, with men being more linked to intensive cycling practices (Ricci, 2015; Vogel et al., 2014). In London, male users tend to use the system on a highly regular basis for commuting purposes, while recreational rides during weekends and in parks are taken mostly by women (Ricci, 2015). A Chinese study also demonstrated that women are more likely to "make multiple-circle bike sharing trip chains (i.e. with multiple destinations but same start and end point)" than men, especially on week days (Ricci, 2015). Other studies support these findings by explaining that women's more complex trip chains are linked to their household and childcare-related activities. Women also prefer taking routes with slower traffic and safe cycling infrastructure, avoiding large multi-lane roads (Ricci, 2015).

A study in Melbourne, Australia, looked at reasons behind people's use of the Melbourne Bike Share system. When asked why they used the scheme, 48% of a survey's respondents said that it was convenient (14% mentioned the proximity of the system to public transport and 10% said that it was close to their work). Ten percent liked the price of the system, 12% mentioned environmental reasons, and 11% mentioned fitness as being a reason for bike-sharing (Fishman, Washington & Haworth, 2012).

Bike-sharing in general is also affected by temperature and climate, with nice weather associated with more cycling. Bike-sharing use is also higher during the week, although Friday and Saturday nights witness a high level of use as well. Bike flow diminishes based on distance from downtown, which can be partly explained by the fact that bike-share use and flow increase when there are more destinations in an area. Population and job densities also influence usage rates, and so does bike-sharing network density. Interestingly, a study on BIXI stations revealed that adding new stations would increase bike flows more than increasing the size and capacity of an existing station (Faghih-Imani et al., 2014). Having cycling infrastructure near a station also contributes to an increase in use, as demonstrated by studies in Montreal and Washington, D.C. (Faghih-Imani et al., 2014; Fishman, Washington, & Haworth, 2013). In London, the proximity of a residence to a cycling-scheme station influences the frequency of use of the system by a user (Ricci, 2015).

3.2. Goals of bike-sharing schemes

Bike-sharing systems serve different purposes, yet work towards common objectives. Most systems are aimed at favouring multimodality and inter-modality in order to create a more integrated and sustainable transportation network. They also aim at promoting sustainable modes of transportation and providing a new flexible mobility option for citizens' utilitarian trips. They are also expected to increase the reach of public transportation by providing a complementary service to transit. Giving citizens more choices and opportunities to reach a destination increases accessibility. Bike-sharing systems can also act as tools to promote cycling as a common, healthy mode of transportation for short-trip distances and daily commuting trips, and not strictly for recreation. They can help normalize cycling practice, increase its levels, and improve its status and image in general. Cycling schemes can also attract new cyclists by diversifying the offer and reducing barriers linked to bike ownership and bike parking. They increase ease and opportunities for people to cycle. Cities can also implement bike-sharing systems to influence transportation and land use planning, for instance by diminishing air and noise pollution; reducing energy consumption; improving residents' quality of life; reducing traffic congestion, single-occupancy car trips and crash risks; reducing costs for roads and parking; and allowing consumers to save money. Other long-term objectives of bike-sharing systems include the improvement of residents' health and levels of physical activity, as well as public health in general. They can also contribute to an increase in safety on the roads and an upgrade in cities' image, branding, and liveability (Ahillen et al., 2016; Cagliero et al., 2017; Carlson, 2015; Fishman, Washington & Haworth, 2012; ITDP, n.d.; Midgley, 2011; Ricci, 2015). Cities can also implement them to boost economic vitality, for instance through their positive impact on local economies and tourism (Ricci, 2015). Finally, they can contribute to creating a stronger sense of solidarity within regions and areas while also supporting "smart growth land use development" (Midgley, 2011).

As we shall see in the next section, cycling schemes meet most of these objectives.

3.3. Benefits and positive impacts of bike-sharing systems

Bike-sharing systems not only contribute to promote and increase cycling, but they also contribute to put cycling on the map of daily transportation modes (Midgley, 2011; Press, 2011). Even if a city's cycling culture is not strong, cycling schemes can allow people to try cycling (Snow, 2017). Bike-sharing reduces barriers for would-be cyclists, and allows people to cycle without the commitment of buying a bike. It addresses the issue of bike theft and maintenance which can be a deterrent to owning a bike. Since the company takes the risk and not the rider, cyclists do not have to fear losing their bikes, having a flat, or

not being able to find parking (Blue, 2016). The systems' apps make it easier for people to access the program and get information about stations' locations and bike availability. Discounts and varied payment options also make the system attractive and accessible to more people (Carlson, 2015).

In many cities with a bike-sharing system, bike sales increase (Snow, 2017). Cycling levels can also rise, with people living in areas with bike-share services starting to cycle or increase their frequency of cycling as a result of the system (Ricci, 2015). In Paris, cycling increased by 70% following the launch of the Vélib' system, and in Lyon, the level of cycling increased by 44% a year after the implementation of Vélo'v (Midgley, 2011). This increase in the number of riders makes cycling safer, as more cyclists on the streets heightens their visibility (Snow, 2017). This also generates more demand and pressure on political leaders to improve street's safety and quality for cyclists (Blue, 2016).

Bike-sharing also serves as a complementary service to public transit by providing a solution to the "first/last mile" problem. This issue relates to the distance between public transport and a user's residence, workplace, or other destination, making it inconvenient for the user to walk and therefore more likely for him/her to use his/her car. Bike-sharing contributes to inter-modality and brings a new form of public transportation. It can help to increase the coverage of public transport and make it more attractive (Blue, 2016; Carlson, 2015; Chen & Sun, 2015; Fishman, NACTO, 2017; Washington & Haworth, 2012; Press, 2011; Ricci, 2015). It also offers a competitive solution when it comes to trip cost and trip length, since it is faster, and more affordable, convenient and flexible for short commuting trips, compared to other modes such as cars, public transit, or taxis (Carlson, 2015; Fishman, Washington & Haworth, 2012; Midgley, 2011; Ricci, 2015; Snow, 2017).

Indeed, for short trips of 3 to 5 km, cycling is a more convenient, fast, and flexible mode of transportation than cars or buses, while in congested situations, it is often the best option for trips up to 8 km (Carlson, 2015; Chen & Sun, 2015). Knowing that 40% of all trips (all modes combined) in the United States are within 2 miles (3.21 km) of home, the potential for cycling trips and for a reduction of gas consumption and pollution becomes significant (Carlson, 2015). Moreover, bike-sharing is usually a less expensive option than motorized modes of transport. For instance, a monthly transit pass in New York City costs US$116.50. Citi Bike's annual membership, on the other hand, costs US$163 (Motivate International, Inc., 2017c; Pope, 2015).

Other benefits related to cycling schemes are the ease and speed of their implementation compared to other urban transportation options. For instance, Paris' Vélib's first 700 stations and 10,000 bikes were installed over a period of 6 months, and half-a-year later the system had doubled in size (Midgley, 2011). Bike-sharing is also a

very safe mode of transportation. Combined with an increase in cycling infrastructure and traffic calming measures, it becomes even safer and more attractive for cyclists (Colon, 2017; Haag & Alani, 2017).

Bike-sharing systems can help people reach destinations that were not previously accessible (Midgley, 2011). Systems also provide a new transportation option for vulnerable populations, such as people in low-income communities (if the system reaches the areas and offers accessible fees) (NACTO, 2017; Snow, 2017).

Research by McGill University concluded that people who commute on bicycles are more punctual and more energized than commuters using other modes of transportation (Loong, van Lierop & El-Geneidy, 2017). Cycling can also make people happier, since feel-good serotonin and dopamine levels start increasing after 20 to 30 minutes of physical activity, and endorphins are released after more than 30 minutes. Moreover, the air drivers breath inside cars is more polluted than the air cyclists breath, especially when cycling on separated infrastructure. Bike-sharing can also contribute to the well-being of communities, encourage community development and participatory planning (for instance through the selection of locations for docking stations), and contribute to the enhancement of local economies. It can also provide users with a new way of experiencing and seeing a city (Carlston, 2015; Ricci, 2015).

Bike-sharing systems can also contribute to the branding and image of a city (Fishman, Washington & Haworth, 2012; Ricci, 2015). A city may also decide to provide electric shared bikes, which can contribute to an increase in cycling by making it easier for some populations, like seniors, or in specific contexts, like hilly cities. Studies have shown than when bike-sharing systems offer electric bikes as an option, electric bikes are used 5 times more often than regular bikes (Gutman, 2016).

3.4. Challenges and opportunities of bike-sharing systems

There are several economic, social, cultural, and physical barriers and challenges faced by bike-sharing systems. One of them is that bike-sharing is rarely profitable, like most public transportation services (Blue, 2016; Snow, 2017). That said, bike-sharing systems have amongst the lowest costs per individual of all public transportation modes. In many cities around the world, public transportation and bike-sharing are subsidized by the government. However, there are also some systems which are not subsidized at all and must rely heavily on user fees to provide a stable revenue source and break-even (ITDP, n.d.). Some of these systems have had to increase their fees to survive or grow their network. This is the case of New York City, whose annual membership increased by

almost 60%, from US$95 to US$149, in order to improve and expand the network. However, increasing prices can have an impact on use and affect people from low-income areas. For instance, after London's system doubled its prices, there was a reduction in casual use, and poor areas were more affected by the increase than richer neighbourhoods (Chaban, 2014; Gastel & Tsang, 2014; Ricci, 2015). Other companies, like PBSC in Montreal, had to declare bankruptcy, be sold, and restructured after years of debt and non-profitability (Goodyear, 2017). There are a few systems whose membership and user fees are enough to sustain the system. Capital Bikeshare, in Washington, D.C., gets around 97% of its costs (excluding marketing costs) recovered, and Boston's Hubway recovers 88% of its costs (ITDP, n.d.).

The size, density, and layout of a system and its stations can create numerous challenges, which can affect its performance and efficiency (Chen & Sun, 2015). A poorly designed system might lead to empty stations with no bikes to rent (if the demand is higher than the supply) or full stations with no space to return a bike (if redistribution is unable to cope with the popularity of some stations) (Carlson, 2015). Density is important, and some systems have suffered from having small systems and no possibilities to expand them. To be successful, programs should aim to have between 20 to 28 stations per square mile, according to experts, but many programs have much lower densities. It is important to have many stations, since people tend to use the systems if they are located close to their origin point, such as their residence (Cohen, 2017; Snow, 2017). Researchers also found that having greater bike availability is good for a system's usage, even if it means that stations are full more often (Snow, 2017). Companies may debate whether to cover new areas or increase coverage within existing service areas. Some systems experienced increased ridership following the expansion of their system. For instance, Boston's Hubway registered 142,289 trips in its first year, for a system of 600 bikes and 61 stations. Hubway later increased its system to 140 stations and 1,300 bikes, and in 2016, it recorded almost 1.2 million trips (Cohen, 2017; Snow, 2017).

The selection of stations' locations can also be problematic. While high-demand locations such as dense, populated areas or cultural, social, and economic activity hubs attract more customers and generate more revenues, there are also other areas which must be covered in order to be equitable. Unfortunately, like in the case of New York City, low-income areas suffer from the fact that bike-sharing companies must cover their operational costs, which means their stations must generate enough revenue so user fees and other revenue sources like sponsorships can allow the company to break-even (ITDP, n.d.; Ricci, 2015). However, even if low-income areas do not generate as much revenue, they should not be neglected, as their inhabitants are in the most need of transportation options (Snow, 2017). The systems' technology might also deter some people from using

bike-sharing. For instance, people who do not have access to credit cards or smartphones can have a hard time using some systems.

Dockless systems can help lower costs and simplify the deployment of a program by not having to implement and maintain stations. At the same time, these new systems also have to deal with their own set of challenges, like parking regulations, bike saturation, GPS struggles, or redistribution issues. The fact that they are new systems also increases the chances of unexpected problems or miscalculations (Snow, 2017).

Bike theft and vandalism can also be an issue. Bike-sharing fleets are designed to deter theft, for instance by having bikes that require a special proprietary tool to be dismantled, which makes them hard to sell for parts. Some systems incorporate bike parts designed to be unique so they cannot be used on other bikes (Chen & Guerrero, 2014). In China, the program Mobike uses a "system of credits to reward good behaviour and punish the bad" (Van Mead, 2017). Users initially have 100 points. Every time they report bad behaviour (like improperly parked bikes) to the company, they get extra credit once the information is verified. As for the user who did not comply with the rules, he or she loses 20 points. When a user has less than 80 points, rental fees are increase considerably (New Mobility Group, 2017; Van Mead, 2017).

Rebalancing the system can also be challenging, as well as labour-intensive. Systems can put in place incentives for users to return bikes to certain points. (Blue, 2016; Cagliero et al., 2017; New Mobility Group, 2017). The University of Virginia's UBike system, which uses dockless bikes by Social Bicycles, charges US$5 to those who lock their smart bikes outside of a station. Users who lock their bikes outside of the system area are charged a US$50 retrieval fee. Moreover, to increase the return of smart bikes to the hubs, users who return a bike parked outside of a station receive a US$3 credit (Social Bicycles Inc., n.d.b). At the University of South Florida's Share-a-Bull Bikes program, a fee of US$35 is charged to users for not locking their bike to a bike rack, while a US$50 fee is charged when the bike is locked outside the system area (Share-a-Bull Bikes, n.d.). The dockless company Mobike, for its part, has designated Mobike Preferred Locations where it encourages its users to park their bikes. Users can also find best parking practices on the company's website and receive credits for reporting bad parking practices (Mobike, 2017; New Mobility Group, 2017).

Fortunately, new technology, such as Station Occupancy Predictor (STOP), will help operators to better predict occupancy levels at stations and adjust redistribution accordingly (Blue, 2016; Cagliero et al., 2017). This also allows for a reduction of operational costs, which can make up to 40% of a system's budget (Snow, 2017).

Programs can also restrict the maximum length of a bike-sharing rentals to make sure that bikes are returned quickly and that stations always have available bikes. In Barcelona, Bicing restricts the use of its bicycles to a maximum of 2 hours. It penalizes its users who exceed the time limit by charging them €4.49 per exceeding hour, and deactivates their account when they exceed the 2-hour limit three times and receive three warnings. After 24 hours, a user who has not returned a bike is charged a fee of €150 (Ajuntament de Barcelona, n.d.).

Mandatory helmet laws are an important deterrent to bike-sharing, and some experts estimate that it can reduce potential use of a system by up to 50% (Snow, 2017). In Australia, the enforcement of a mandatory helmet law in the beginning of the 1990s led to a significant decrease in cycling modal share compared to levels registered before the law was enforced. It led to a reduction of at least 30% of public cycling levels. A 2017 national survey also noted that cycling participation was declining significantly since 2011 (Blue, 2015; Colon, 2017; Ghillam, 2014; Milman, 2015). Moreover, studies have shown that the amount of hospitalizations of cyclists did not decrease in absolute numbers, and that the rate of death and serious injury increased by 30% between 1992 and 2000 (Hiles, 2016/2017). In 2012, the Cities of Sydney, Perth, Fremantle, and Adelaide requested an exemption or repeal of the law in order to encourage the practice of cycling. The move could also help the country's current bike-sharing systems in Melbourne and Brisbane, as well as future systems in others cities. The two current systems have experienced very low ridership levels since their launch in 2010, and in Brisbane, the system's poor performance has led taxpayers to pay more than US$6 million in subsidies since its launch (Dick, 2015; Ghillam, 2014; Gutman, 2016; Rachele, Badland & Rissel, 2017). In New Zealand, where a mandatory helmet law was also implemented around the same time, similar results were found. The number of hours cycled per person dropped by 51% after the enforcement of the law, and cycling modal share also dropped from 4% in 1989 to 1% in 2006 (Ghillam, 2014; Milman, 2015; Rachele, Badland & Rissel, 2017).

One of the reasons behind the negative impacts of mandatory helmet laws is that they reduce the spontaneity and convenience of bike-sharing. People can also be loath to use helmets provided at bike-sharing stations (Cohen, 2017; Dick, 2015; Gutman, 2016). A survey on Melbourne Bike Share showed that helmet issues were the main barrier to a widespread use of the system, with 61% of respondents selecting it as the main deterrent (36% said it was hard to find a helmet, and 25% did not want to wear one). In comparison, 9% of respondents claimed safety concerns while 8% said it was too expensive (Fishman, Washington & Haworth, 2012).

Mandatory helmet laws also discourage cycling in general, making it less safe when considering the "safety in numbers" phenomenon (Colon, 2017; Snow, 2017).

Indeed, more bikes on the road makes drivers more aware of the presence of cyclists (Gutman, 2016). Advocates against mandatory helmet laws point out that there are no mandatory helmet laws in Europe or China, where bike-sharing is flourishing (Gutman, 2016).

In Australia's Northern Territory, the mandatory helmet law was changed in 1994 to allow people to ride without helmets when they bike along trails and bike paths. This resulted in the territory having the highest rate of work commuting by bike, with 3.4%, compared to 1.3% for the rest of the country. Women also commute more by bike in the territory (37% of the total number of cyclists compared to 26% in the rest of the country) (Ghillam, 2014; Milman, 2015; Rachele, Badland & Rissel, 2017). A few places in the world have repealed their mandatory helmet law. Dallas, in Texas, did so in June 2014 in the lead up to the launch of a bike-sharing system, while Israel allowed people to cycle without helmets when on bike paths in 2011, leading to a 54% increase in cycling modal share in Tel Aviv between 2010 and 2012 (Cohen, 2017; Gillham, 2014; Gutman, 2016). Mexico City also repealed its law in 2010, one year after implementing it, in order to help its upcoming bike-sharing system ECOBICI, which has since been successful (Blue, 2015; Cohen, 2017; Donovan, 2017; Rachele, Badland & Rissel, 2017). In March 2017, Bosnia and Herzegovina repealed its mandatory helmet law after 6 years of campaigns, becoming the first country to do so (Reid, 2017).

Some bike-sharing systems distribute helmets. Pronto! in Seattle, where there is a mandatory helmet law, did so until it closed in March 2017, and Melbourne Bike Share started distributing helmets soon after launching. Boston's Hubway system, in partnership with HelmetHub, launched a pilot project in 2013, where people could rent a helmet for 24 hours at a cost of US$2, or buy one from a HelmetHub vending machine for US$20. Free helmet rental was offered to those qualifying for subsidized Hubway memberships, and low-cost helmets were also available through the organization Boston Bikes and Hubway's website (DeLuca, 2014; Gutman, 2016). In Brisbane, 900 helmets were distributed across the CityCycle fleet in the second half of 2011. They were placed on "handlebars, in bike baskets, or secured on the locking mechanism that held the bike to the docking station" (Fishman, Washington & Haworth, 2012). This led to an increase in short-term trips, since people had easier access to helmets. However, bikes with helmets were the first to be taken, making it hard to get a helmet during peak hours (Fishman, Washington & Haworth, 2012).

Experts recommend that, instead of mandatory helmet laws, cycling infrastructure be built to make cycling safer. However, there are still places considering the implementation of mandatory helmet laws. In summer 2017, the State of New York received a sponsored bill to change the current helmet law, which applies to children

under 14 years old, so it would apply to adult cyclists. The bill, which is currently being debated, will be voted on next year (Colon, 2017; Snow, 2017).

Brisbane's CityCycle system provides many examples of additional struggles that can be faced by bike-sharing schemes. The system had to contend with not only a mandatory helmet law, but a lengthy sign-up process, which took days. These factors helped kill the spontaneity that usually attracts bike-share riders. As of 2012, the city also lacked cycling infrastructure which, combined with high motor vehicle speed and car drivers' negative attitudes (although their attitudes improve when cyclists are on a CityCycle instead of a personal bike), led people to not feel safe on the road. Lack of safety (or the perception of it) is an important deterrent to the use of bike-sharing schemes. The system's accessibility was also criticized, since it was closed between 10pm and 5am. It did not accept credits cards, its website was not user-friendly, and the mobile app did not work well. Marketing strategies were deemed inefficient, and the system suffered from a lack of visibility. The fact that residents did not see other people using the scheme also reduced the attractiveness of the system, which needed greater incentives to attract new casual users and members. Weather and geographical conditions, such as heat, rain, and hills, were also seen as potential deterrents for cycling (Fishman, Washington & Haworth, 2012; Snow, 2017). To rectify the situation, researchers recommended that the system be linked to the local public transport smartcard, that docking stations be added in residential and suburban areas, and that it be better integrated with public transport. Automated sign up should be made available, and the system should be open 24/7. Access to helmets should be increased since they are mandatory in Australia, and strategic marketing should be rethought to reduce barriers to membership and attract people to the system (like reducing prices or offering a two-for-one deal at the launch of the system) (Fishman, Washington & Haworth, 2012).

Perceptions of bike-sharing's effects and benefits can also be incorrect or exaggerated. For instance, bike-sharing is often seen as a good method in the fight against CO_2 emissions and replacing car trips. However, some studies showed that bike-sharing systems do not necessarily have an important impact on car use and the environment (Bachand-Marleau, Fishman, Washington & Haworth, 2014; Larsen, & El-Geneidy, 2011; Guénette & Doucet, 2017; Ricci, 2015; Société Radio-Canada, 2010). A study in Montreal found that "[in] most cases, bicycle sharing usage replaces trips previously made by other "green" modes, namely public transit, bicycle, or walking" (Bachand-Marleau, Larsen, & El-Geneidy, 2011). Only 2% of trips made with the local BIXI system replaced trips previously made by car, while approximately 8% replaced taxi trips. The study also revealed that 33% of BIXI trips replaced a transit trip, 28% were previously made by bike, 25% replaced a trip made by foot, and 4% added a trip which would not have been made

otherwise. Therefore, the system's impact on the environment in terms of CO_2 can be seen as negligible, and "official estimates of CO_2 reduction because of the implementation of the program are exaggerated" (Bachand-Marleau, Larsen, & El-Geneidy, 2011). Another study concluded that due to bike maintenance and redistribution, bike-sharing systems actually increase motorized vehicle use (Fishman, Washington & Haworth, 2014; Ricci, 2015). Other studies, on the other hand, say that bike-sharing systems can reduce car use if redistribution and maintenance of the system is adequate and do not generate more car use than what is being replaced by cycling scheme trips. (Chen & Sun, 2015; Midgley, 2011; Ricci, 2015). In terms of environmental impact, the recent boom of dockless systems in Asia has led to massive productions of shared bikes which are not all being used. This contributes to overconsumption and unsustainability (Douglas, 2013; Kolodny, 2017; Larsen & Dissing Christensen, 2015; Lloyd, 2017e; Meddin & DeMaio, 2017; National Association of City Transportation Officials [NACTO], 2017c).

There are some personal and cultural contexts to consider as well when it comes to bike-sharing systems. For instance, the fact that trips must be under 30 or 45 minutes to avoid paying a fee creates constraints for users whose ride would be around or above this amount of time. Some people may prefer to ride their own bike rather than walk to a station and find an accessible bike (Carlson, 2015). In some cultural contexts, cycling's perception can vary. For instance, in Kenya, cycling is often associated with poverty, and for that reason, some may be hesitant to adopt this mode of transportation (Bryce, 2016). Some bike-sharing systems have tried to attract people that usually do not bike. For instance, Vélo'v has special offers for businesses and organizations, and several programs in the United States offer discounts for low-income people (Métropole de Lyon, n.d.c.).

CHAPTER 4:
METHODOLOGY

Since the relatively recent bike-sharing phenomenon comprises of very different systems and contexts around the world, we chose to use the case study research method to compare and address these differences and see how they can impact a system' success or lack of it. In the next chapters, four case studies will be analysed in detail: Montreal's BIXI, New York City's Citi Bike, Seattle's Pronto! and DECOBIKE San Diego.

Adopting a comparative multiple-case study method allows us to examine the facts and empirical data of significantly different cases and evaluate how contextual conditions, or variables, have influenced each system's performance and outcomes. Comparisons between these case studies led to the formulation of some analytic generalizations applicable to North American systems. Based on these, we offer recommendations to cities wishing to implement successful schemes (Yin, 2014).

We defined a bike-sharing system's success by its high level of ridership, combined with high popularity and support from citizens and other involved stakeholders. We chose these criteria as they are the main ones usually considered in the grey literature on the subject. After reading through the literature, we decided not to include the level of financial revenues of a system in our list of criteria for successful schemes. The reason is that very few systems break even, including many that are highly successful in the other categories mentioned above (Blue, 2016; Snow, 2017). Therefore, to include these criteria would have limited our number of options of successful bike-sharing systems considerably, and would have excluded interesting and complex cases such as Montreal.

For the unsuccessful cases, we looked for systems which experienced low levels of ridership or received heavy criticism or backlash from local citizens or organizations. Here again, the financial solvency of systems was not considered a prime factor in our selection of cases. Moreover, some "successful" cases also faced problems, but since they continued to attract users and support, we still considered them "successful."

The number of case studies was chosen in order to provide a diversified range of cases including very successful systems and others which had not received a lot of attention or were said to be experiencing difficulties. Due to time considerations, we had to restrict ourselves to two cases for each category, though the study could have compared many more systems. For instance, the American east coast is home to several successful bike-sharing systems, such as Washington, D.C.'s Capital Bikeshare or Boston's Hubway (Cohen, 2017; ITDP, n.d.; Snow, 2017). However, unsuccessful systems in North America have not received much attention from academic literature, and many studies and papers looking at struggling bike-sharing systems have focused on schemes in other parts of the world, such as Australia (Fishman, Washington & Haworth, 2012). This helped restrain

our research analysis to four official case studies (although several other systems are mentioned throughout this study).

The systems were mainly chosen based on their level of ridership, their perception by the population and media, their role in the bike-sharing sphere in North America as well as their complexity. Comparisons in terms of finance, size of the system, geographical coverage, and political context were also performed to select cases that were complex representations of both successful stories and failed implementation. For instance, Montreal's BIXI's high ridership levels and popularity amongst local residents helped compensate for the system's financial and structural struggles, eventually turning the system into a success story despite its difficulties and insolvency. Its status as a pioneer system in North America and innovative technology contributed to its selection as one of the four case studies (Austen, 2015; Bérubé, 2017; CBC News,2014 & 2017; Faghih-Imani & al., 2014; Goodyear, n.d.; Magder, 2015; Messahel, 2016; Strini, n.d.; Tools of Change, 2013). New York City's Citi Bike also encountered success in terms of ridership, while facing organisational and operational challenges, amongst other problems. The degree of support it has received from authorities and the public contributed to its selection for this study (Carlson, 2015; Chaban, 2014; Flegenheimer, 2014; Goldberg, 2014; Haughney, 2011a; Kessler, 2015; Kuntzman, 2017; Motivate International, Inc, 2017a; NACTO, 2017a; Sadik-Khan & Solomonow, 2016; Seaton, 2012; Sugar, 2016; Tangel & Hufford, 2016).

DECOBIKE San Diego was selected mainly based on negative descriptions of the system's situation in newspapers and online resources. The scheme has not been studied academically, therefore grey literature became the main source of evidences. Most articles were unanimous on the struggles faced by the system, not only in terms of ridership, but also in terms of popularity and support amongst the local population and other stakeholders. The different business approaches of the bike-sharing company running the system in San Diego also added another point of comparison and increased the level of complexity of the case, making it particularly interesting to analyse (Garrick, 2016; Lozano, 2015; Ogul, 2014, San Diego County Grand Jury, 2016; The San Diego Union-Tribune Editorial Board, 2016; Schwab, 2016a & 2016b; The San Diego Union-Tribune Editorial Board, 2016; Trageser, 2016). As for Pronto!, the high mediatisation following the closure of the system in March 2017 brought this system at the front of the bike-sharing scene. It provided an excellent example of a scheme which, despite being located in a large city, experienced difficulties to the point of having to terminate operations. The degree of uncertainty in the media regarding the main cause of the system's low ridership levels made this case even more intriguing and contributed to its selection (Barber, 2017; Beekman, 2016; City of Seattle, 2017b; Cohen, 2017; Dornfeld, 2016; Golliver, 2016;

Gutman, 2016 & 2017b; Lloyd, 2017d; Macz, 2017; Office of the Mayor, 2017; Robertson, 2017; Small, 2017; Soper, 2016).

It is important to mention that only North American cases were examined in the selection process. This was done in recognition of the different political, social, cultural and historical contexts that define different geographical contexts. As seen in the literature, bike-sharing systems did not start nor evolve in North America the same way as they did in Europe or Asia, for instance (Shaheen, Guzman & Zhang, 2012). Even within the continent, each city has its own context and history, which can mean similar systems have very different outcomes in spite of their similarities. With this in mind, this research will try to find factors that seem to generally impact positively or negatively systems in the United States or Canada.

To collect the data and select the case studies, we relied on multiple sources of evidences (Yin, 2014). These sources included both academic and grey literature in the forms of: scholarly publications and academic reports; bike-sharing companies' and projects' websites, informative and promotional documents; general sites on bike-sharing; official online sources and publications, like guidelines and manuals; newspaper articles; and information platforms. Researchers who contributed to the scholarship on bike-sharing systems also consulted these types of sources, and we used them to build the in-depth literature review in Chapter 3 (Ricci, 2015).

While searching for extensive information on the selected case studies online, we usually relied on the first five pages of results provided by search engines. These were often enough to collect a large sample of websites, articles, papers, and similar documents with relevant information on each case study. References within those documents were then used to gather additional data and complement the information. The diversity of sources ensured the inclusion of various perspectives on the different case studies, and allowed us to draw objective and informed conclusions from which we can offer recommendations for the success of current and future bike-sharing systems.

The theoretical framework for the case studies' analysis includes the following components and key variables (Regoniel, 2015; University of Southern California, 2017):

- Types of systems in terms of generation and technology (dockless system versus solar-powered stations, third versus fourth generation, etc.);
- Schemes' ownership and organizational structures (privately-owned system vs publicly-owned, etc.);
- Financial models, including support, funding and revenue sources;

- Logistical and technological issues encountered by systems' operators, promoters and/or providers, which can greatly influence the schemes' reliability and efficiency;
- Factors that can encourage ridership, such as inter-modality, the integration of bike-sharing and public transit, the size and reach of systems, accessibility matters and cities' transportation infrastructure;
- The attitude of systems' promoters and/or operators towards their population, including degrees of transparency, selected outreach and marketing methods, and the consideration of local needs and marginalized populations;
- Political factors, such as regulations (mandatory helmet laws, etc.), and cultural matters like the presence of a cycling culture, cultural perceptions of cycling, etc.
- Environmental factors, such as topography or climate.

Case studies will be analysed in depth in the next chapters to assess the impacts of those factors on the systems' performances. While Chapter 5 looks at each case study separately, Chapter 6 combines findings in order to draw analytic generalizations and offer recommendations, which are available in Chapter 7 (Yin, 2014).

CHAPTER 5:
CASE STUDIES

5.1. Selection of the four case studies

In order to have a balanced combination of successful and struggling cases, four cases studies were selected. Two systems were selected to represent good practices, while two others were chosen because of the bumpy road they have encountered since their launch. For greater homogeneity regarding cultural, historical, and urban contexts, only North American case studies were studied. Mexico City's highly successful ECOBICI was not included in the options because of its very different context, in comparison to other North American cities.

New York City's Citi Bike was a clear case study candidate, since it is one of the most successful systems in the United States, despite the uncertainties and criticisms that characterized its pre-implementation and debut phases. Montreal's BIXI system was selected because it overcame initial struggles that almost led to its death. Other successful systems could have been selected, but these two represented good examples of programs that faced major challenges and yet became extremely popular in spite of them. In that sense, the cases offer insight into key factors in the success or failure of a bike-sharing system, and demonstrate responses to challenging factors.

Seattle's Pronto! system was selected following the decision of the City of Seattle to shut down the system at the end of March 2017. The system had been struggling since its beginning and therefore was an ideal case for this study. As for San Diego, research of the grey literature revealed that the system has had numerous issues since its early stages, while also being one of the only non-subsidized programs in the country. As such, it was a rich case study to include for its look at how the business models and outreach/participatory approach can impact the outcome of a system.

5.2. Montreal's BIXI

5.2.1. Overview of the city

Montreal is a Canadian city located in the southern part of the province of Quebec. It is the largest city in the province and the second largest in Canada (after Toronto) with a population in 2016 of 1,704,694 inhabitants and a population density of 4,662.1 inhabitants per square km. This represents an increase of 3.3% compared to 2011 data. The Montreal metropolitan region had 4,098,927 inhabitants in 2016 and a density of 890.2 inhabitants per square km (Statistics Canada, 2017). It is the 19th largest metropolitan region in North America in terms of population, just ahead of Seattle (WorldAtlas, 2017b).

Montreal is one of the most diverse cities in North America, thanks to its large immigrant population and particular history. While the growth in total population in the

city has been slow compared to other North American cities, the immigrant population has grown considerably over the last decades (World Population Review, 2017a). Although the largest ethnic groups have European origins, around 31% of the city's population describes themselves as belonging to a visible minority, a significant increase compared to 5% in 1981. The largest groups of visible minorities include Black (9.1%), Arab (6.4%), Latin American (4.2%), South Asians (3.3%) and Chinese (2.9%) (World Population Review, 2017a). The city population's average age is 40.3 years old (Statistics Canada, 2017).

Montreal's cold and temperate "humid continental" climate is characterized by significant rainfall and humidity all year long, warm summers, strong seasonality and severe snowy winters (CantyMedia, 2017; Climate-Data.org, n.d.a; ClimaTemps.com, 2017). The total annual precipitation averages 1016.5 mm, and the average number of hours of sunshine per year is 1860. The city's annual mean temperature is 5.9 ^{0}C, with average high and low temperatures in the winter of -4.1 ^{0}C and -13.4 ^{0}C, compared to 25.1 ^{0}C and 13.2 ^{0}C in the summer (ClimaTemps.com, 2017).

The City of Montreal comprises of the majority of the island of Montreal. While it is mostly flat, some neighbourhoods lay at the foot of Mount Royal (height of 233 m). The average elevation of the city is close to 30-35 m above sea level (ClimaTemps.com, 2017; Environment and Climate Change Canada, 2017).

5.2.2. Montreal's bike-sharing system: main facts

City:	Montreal, Quebec, Canada
Name of bike-sharing system:	BIXI
Date of launch:	May 12, 2009
Owner/Promoter:	First, Stationnement de Montréal, then SVLS (PBSC), then BIXI Montréal
Operator:	First, Stationnement de Montréal, then SVLS (PBSC), then BIXI Montréal
Equipment provider:	PBSC then PBSC Urban Solutions
Number of bikes & stations at launch (and now):	3,000 bikes at 200 stations (6,250 bikes at 540 stations)

Table 3. BIXI's main facts.

Montreal' BIXI system was launched on May 12, 2009 with 3,000 bikes at 200 stations. Quickly, the system's popularity encouraged authorities to expand the system, and within a few months of the program's launch, BIXI offered 5,000 bicycles at 300

stations (CBC News, 2009; Cooper, 2009). In 2012, the system increased its number of docking stations to 410 (Faghih-Imani et al., 2014). In April 2017, thanks to its popularity, the system was extended again, with an additional 80 stations, 1,000 bikes and 2,214 anchor points. The system has a total of 6,250 bikes over 540 stations located in Montreal, Westmount and even off-island in Longueuil (Bérubé, 2017; BIXI Montréal, 2017a).

While Stationnement de Montréal was the entity responsible for the system at first, it was quickly given to a newly-created organization, Service de vélos en libre-service (SVLS), or Public Bike System Company (PBSC). The company was in charge of the system until 2014, when it filed from bankruptcy protection. The operational branch of PBSC was subsequently bought by the City of Montreal and a new entity, a non-profit called BIXI Montréal, was created to operate the program (Austen, 2015; CBC News, 2016; CBC News, 2014; Magder, 2015; Messahel, 2016; Stationnement de Montréal, 2011; Strini, n.d; Tools of Change, 2013).

Although the company PBSC was expected to quickly become self-sufficient, it didn't. The City of Montreal had been providing funds to the system since its beginning (see section *Successes and challenges* for more details about the financial and structural issues).

BIXI's current sponsor is Manuvie. The company contributes to some of the program's services like the BIXI Manulife Valets and the Free BIXI Sundays. Other current partners include the City of Montreal, Microcom, Lolë, La Presse, Ici Première 95.1, Rachelle-Béry, Vélo Québec, Transit App, and Astral (BIXI Montréal, 2017c) Previous partners include telecommunications company TELUS, mining company Rio Tinto Alcan, and financial cooperative Desjardins. Their logos appeared on the bikes for a few years, and their sponsorship contributed to about 50% of the company's revenues at some point. PBSC tried to get more sponsors by doing presentations to businesses and at conferences. Other revenues came mostly from members and users' fees (Tools of Change, 2013).

The bikes are produced by Montreal-based Public Bike System Company – PBSC (Chicoutimi-based Devinci builds the bikes, while PBSC owns the patents) (Fucoloro, 2014; Magder, 2015; PBSC Solutions Urbaines, 2017). The bike and station were conceived by industrial designer Michel Dallaire, and garnered great praise (Austen, 2009). The first 5,250 bikes were built based on the regular model produced by the company, with three gears and a GPS chip (Austen, 2009; BIXI Montréal, 2017a; CBC News, 2009). Their robust aluminium frame and other components were designed to deter vandalism and theft while also requiring minimum maintenance. For instance, chain tensioners were added by the designer when he discovered that Paris' Vélib's fleet often broke down due to slack chains. On the other hand, the bikes were heavy which made them slower to ride (Austen,

2009; CBC News, 2009). In 2017, 1,000 new bikes with seven speeds were added to the fleet. Moreover, 375 of these bikes were created with special visuals created by artists, designers and citizens through a competition in honor of Montreal's 375th birthday (BIXI Montréal, 2017a). The value of a BIXI bike was estimated at US$3,000 by the New York City's Department of City Planning (2009), while its replacement cost was evaluated at US$1,270. Other sources provide lower numbers, such as CAN$2,000 per bike (CBC News, 2009).

BIXI is famous for showcasing a new model of sustainable and flexible bike-sharing stations which has been replicated since in many other cities. The solar-powered, wireless, and modular stations provide great flexibility in terms of implantation, location and removal, while also requiring no preparatory work before installation. This is a significant advantage in Montreal, considering that the system has to be removed and stored during the winter, as well as for construction and road repair projects. It also allows for adjustment in terms of the station's location and size (Austen, 2009 & 2015; ITDP, n.d.; Mátrai & Tóth, 2016; Midgley, 2011). They were built by Montreal-based Robotics Design Inc. (Magded, 2015).

Figure 10. BIXI station. Source: Reuben, 2011.

Figure 11. BIXI's solar-powered, modular station. Source: Ratthé, 2009.

The inauguration of new multimodal technology in 2017 allowed citizens to rent a BIXI with their Opus public transit card at any of the 540 stations, a first in North America. Users can rent a bike through their smart phone by using either the BIXI MONTRÉAL app or Transit, a Montreal-based multimodal transportation app (Bérubé, 2017; BIXI Montréal, 2017a).

Before the system's launch, market research, as well as surveys were conducted to identify the initial target audience and key locations for the first stations. Results showed that the target audience was mostly young professionals aged 25 to 34, who had median incomes and used transit regularly (Tools of Change, 2013). The system was conceived in part to meet their needs. Stations were installed in central neighbourhoods of the city, including near transportation hubs. After launching, the company quickly took into account requests for new stations and started implementing others. It also looked other target audiences like seniors and tourists.

The system is open from April 15 to November 15. During the winter, bikes are stored in various locations. Since winter 2014-2015, 460 anchoring stations are stored in the interior parking of the Olympic Stadium. The large quantity of equipment in one unique place allows technicians to maintain, update, and deploy the stations in a more efficient way in terms of time and staff (Parc olympique de Montréal, 2015; Riga, 2016).

As of 2017, the program is still not profitable, and seen as a public transit system (Messahel, 2016). Despite facing important costs, the City of Montreal confirmed in 2017 that BIXI is here to stay and that the City was treating it like a form of public transport, and therefore did not expect it to be profitable necessarily (Société Radio-Canada, 2017).

5.2.3. Rates and use options

At its launch in 2009, the system offered an annual subscription for CAN$78, which could be reduced by half if the user also owned a transit-pass. Monthly subscriptions were offered for CAN$28, while daily passes were CAN$5. Day users had to pay by credit card and accept that a security hold of CAN$250 be put on their credit cards by the system to deter theft and vandalism. While the first half-hour was free, the subsequent ones were charged CAN$1.50 each up to 2 hours, after which each additional half-hour was charged CAN$6.00 (Austen, 2009; CBC News, 2009).

BIXI Montréal concluded an agreement with transport companies car2go and Téo Taxi to allow their members to get rate reductions with BIXI. Users of the Société de transport de Montréal (STM), the Agence métropolitaine de transport (AMT), as well as members of Communauto, CAA, Vélo Québec and Accès Montréal, have access to discounts on BIXI services (BIXI Montréal, 2017a). Car2go members can receive a CAN$15 discount on the annual BIXI membership, CAA members are eligible for a 10% discount, and Accès Montréal cardholders can benefit from a 20% discount. Users who register to both annual BIXI and STM memberships save CAN$20 on their BIXI membership and CAN$39 on the OPUS card, while Communauto members who subscribe to the auto+bus DUO program receive a credit of CAN$59. Normal Communauto users can get a CAN$15 discount on a BIXI annual membership, while BIXI users can also get a CAN$15 discount on a Communauto membership.

In 2017, the system started offering new rates and promotions. It established a new 90-day membership option which replaced the less flexible half-season membership. It can be bought at any time during the season for the same CAN$55 cost than the half-season membership. A ten-ride package was also added. It costs CAN$25 and includes 10 one-way rides of 30 minutes or less. Finally, groups could get a 20% reduction on rates until the 1st of June, 2017 (BIXI Montréal, 2017a & 2017c). Since June 1st, groups of 20 people buying annual memberships receive a 10% discount on the price. Multi-user keys allow a group of people to share an annual membership. The membership includes the first full hour free, and cost CAN$240. (BIXI Montréal, 2017c).

In 2017, the annual membership costs CAN$89, daily passes still cost CAN$5, and monthly memberships cost CAN$30. Annual, 30-day and 90-day memberships include the first 45 minutes at no cost, while the first additional 15 minutes is charged CAN$1.75, and the following are charged CAN$3. The 24-hour pass includes only the first 30 minutes at no cost. It is also possible to get a one way short-term access for CAN$2.95. This is usable for a single ride of 30 minutes or less. Packages of BIXI's flexible 2-way passes are also available, with each trip costing CAN$2.50 instead of CAN$2.95 A 3-day access pass

is also offered for CAN$14, which includes the first 30 minutes at no cost. Some of these short-term options require a CAN$100 security deposit. (BIXI Montréal, 2017b).

5.2.4. Successes and challenges

BIXI's history is marked with financial struggle and ownership issues. The idea of launching a bike-sharing system was put forward following the publication of the City's 2008 Transportation Plan (Tools of Change, 2013; Ville de Montréal, 2008). At first, the city's parking authority, Stationnement de Montréal, was in charge of overseeing the system, the first large-scale cycling scheme in North America. The semi-autonomous entity was chosen partly because it had expertise working with municipal infrastructure and street furniture. It also had expertise with wireless technologies like the one that would be needed for the cycling scheme (Tools of Changes, 2013). For instance, its solar-powered payment terminals for cars inspired the concept behind BIXI's stations. The City invested CAN$15 million in the development and launch of the system with the thinking that the system would become financially self-sufficient. Stationnement de Montréal counted on user fees and advertisements on the bikes, as well as seven patents it had secured for the system, in the hope of selling the technology to other cities through the creation of an international business branch. It expected that the company's revenues would cover the costs of BIXI's operations and expansion (Austen, 2009 & 2015; Bloomberg News, 2014; CBC News, 2009; Le Devoir, 2014; Magder, 2015; Vailles, 2014). In the following year, Stationnement de Montréal spent more than CAN$30 million on the project. It realized the system was so costly, it would not be able to pay parking revenues to the City (Bruemmer, 2017). The organization detached itself from the program and created a new para-municipal company, *Société de vélos en libre-service – SVLS* (Public Bike System Company – PBSC). Stationnement de Montréal transferred BIXI ownership and operations to PBSC, and was refunded all advances it had made to the system (CBC News, 2016; Stationnement de Montréal, 2011; Tools of Change, 2013).

PBSC had two branches: one in charge of running the operations and providing the equipment for BIXI, and one focused on selling the BIXI concept and equipment to other cities in the world. The international business branch was successful in exporting the BIXI concept to other cities, and in 2015 it had sold 45,000 bikes in 16 cities around the world (Magder, 2015). However, the company faced issues early on. Its operational branch was not profitable. BIXI's operating costs were higher than predicted, while users' rates had been set too low, quickly leading to large deficits and debt on the operational side of the company. (Austen, 2015; Vailles, 2014). In 2012, total company revenues reached CAN$49.6 million instead of the CAN$91 million expected, and instead of generating CAN$11 million in profits, PBSC lost CAN$2.8 million (CBC News, 2012). The following year, its activities brought in CAN$63 million, including CAN$57 million through its

international branch, but this amount was not sufficient to cover the operational branch's expenses. The company was also failing to make money with its 22 contracts, which forced it to enter bankruptcy protection in 2014 (Austen, 2015; Vailles, 2014).

In 2012, PBSC decided to create its own software, following a dispute with 8D Technologies, the designer of the system's initial software. This move proved to be unwise and led to major problems. The new software suffered from glitches. Some cities had chosen PBSC as the provider for their system because of 8D Technologies' software. This change in the product therefore led to conflicts between the company and its customers (Austen, 2015). Cities experiencing problems with their schemes lost trust in the system and company (Magder, 2015). Cash-flow problems also started around the same time. (CBC News, 2014) In addition, the business branch of the company was offering unprofitable services to its clients, such as taking on charges related to service call centres for North American cities using the PBSC system (Magder, 2015; Messahel, 2016). These difficulties happened at a time when the number of competitor companies started to grow steadily. Many of these companies had better, more sophisticated hardware and software, like smartphone apps (Austen, 2015).

The company's problems with software bugs continued and led the operators of New York and Chicago's systems to withhold payments of US$5.6 million (Bloomberg News, 2014; CBC News, 2014; Magder, 2015). Meanwhile, the system was also experiencing shortages of pieces and products with some of its other clients (Austen, 2015).

The City of Montreal repeatedly tried to help the system to get back on track, approving in 2011 a CAN$108 million bailout package. CAN$37 million was a loan directed towards the operation branch, while the other CAN$71 million went to the international business branch. Despite this new injection of funds, the organization kept failing to provide financial statements (Austen, 2015; CBC News, 2014).

Following recommendations by the new Mayor of Montreal, Denis Coderre, the company filed for bankruptcy protection on January 20, 2014 (Austen, 2015; CBC News, 2014; Magder, 2015; Messahel, 2016; Strini, n.d.). At the time, PBSC was CAN$46.1 million in debt, including CAN$31.3 million owed to the City of Montreal, and CAN$5.3 million to National Bank, which was secured by the City (Bloomberg News, 2014; CBC News, 2014; Magder, 2015). The City of Montreal, wishing to save the system, acquired the equipment and operational branch of PBSC for CAN$11.9 million, and created a new non-profit company to run the system, BIXI Montréal (Austen, 2015; CBC News, 2014; Le Devoir, 2014; Magder, 2015; Messahel, 2016; Strini, n.d.). This move was criticized by many who feared history would repeat itself. Some wanted the city's transit agency, the

Société de transport de Montréal, to take over the management of the system (CBC News, 2014; Le Devoir, 2014). The City also provided the new company with "'management revenues' of CAN$4 million, a start-up grant of CAN$165,000 and a loan of CAN$460,000 for the purchase of capital assets" (Guénette & Doucet, 2017). New management strategies were implemented, and some activities previously carried out by subcontractors, like bike redistribution, were transferred to BIXI Montréal in order to save money. The software managing the redistribution was also improved, which increased the efficiency of the system (Messahel, 2016).

The international business branch of PBSC, with its patents, software, and contracts, was bought by a real estate developer and a business person for CAN$4 million. All the money went to the City of Montreal, leaving others creditors without dividends (as of summer 2017, creditors filed a lawsuit against the City of Montreal to recoup their investments) (Austen, 2015; Castilloux, 2017; Magder, 2015; Vailles, 2014). The deal almost fell through when the company that would become Bikeshare Holdings LLC, the owner of Motivate, made a higher counteroffer. In the end, the Quebec Superior Court decided to refuse the counteroffer (Godyear, 2014). As for the City of Montreal, it did not want to acquire the international business branch, and the Quebec government was not comfortable with the idea of having one city sell products to another (CBC News, 2016 & 2012). The business branch became the company PBSC Urban Solutions, a completlt separate entity from BIXI Montréal. It focuses only on providing bike-sharing equipment to cities and other customers, including Montreal's BIXI system (Magder, 2015). Following the restructuring of the company, it had to renegotiate all its contracts with cities and operators (Vailles, 2014). Meanwhile, its former partner Alta Bicycle Share became its competitor when the latter concluded an agreement with PBSC's former software supplier 8D technologies. 8D and Motivate merged their companies at the beginning of 2017 (Austen, 2015; CNW Group Ltd., 2017). Among the big changes made to PBSC, the company stopped providing unprofitable services, delegating them to the system's owners and operators. PBSC Urban Solution stayed in charge of the equipment, having more than 100 patents in 45 countries, and stopped its involvement in the operational side of bike-sharing. The company became purely a provider, leaving repairs and or maintenance of the equipment to other parties (Magder, 2015). This changed in early 2017, when PBSC Urban Solutions, now profitable, launched a new bike-sharing operator company, Shift Transit (Shift Transit, 2017). Since its restructuring, PBSC Urban Solutions' business has been steady. At the end of 2016, 50,000 bikes made by the company (before and after the split from BIXI Montréal) were in operation around the world. The company plans to continue expanding, with new markets and products, such as an electric bike (CBC News, 2016).

BIXI Montréal was heading in a better direction following the restructuring, although it caused a loss of CAN$1.5 million in the year following the split (CBC News, 2014). In June 2015, BIXI announced it had generated a surplus of CAN$818,275 for the 2014 season, of which CAN$460,000 would be used to pay for the new redistribution trucks, and the remaining CAN$165,326 would be returned to the City of Montreal to reimburse the start-up subsidy (CBC News, 2015). The system generated in 2016 a surplus of CAN$654,075 (Société Radio-Canada, 2017). The same year, the City provided the system with an additional CAN$10 million to buy additional bikes and docking spaces, as well as new stations and replacement equipment (CBC News, 2017).

The grants provided by the City have allowed BIXI to survive since its inception – without them, the system would never have seen a surplus (Le Devoir, 2014; Guénette & Doucet, 2017; Mátrai & Tóth, 2016). For instance, in 2015, the system generated a surplus of CAN$281,996, but without the City's money, the system would have been in a deficit of CAN$3 million (Guénette & Doucet, 2017).

Moreover, the City of Montreal has been faced with lawsuits (including one for CAN$37 million and one for CAN$4 million) regarding BIXI since 2014. These have cost taxpayers another CAN$1 million (Houde-Roy, 2017; Société Radio-Canada, 2017). In April 2017, one of the lawsuits required the City of Montreal to pay "$16 million [with interests, $18 million] to the creditors of the bankrupt company that once managed Bixi" (Bruemmer, 2017). The City decided to appeal the Superior Court's decision (Castilloux, 2017). A 2017 study also showed that in 2019 BIXI will have cost Montreal CAN$60 million over 10 years, or CAN$6 million per year (this number does not include the CAN$16 million for the lawsuit) (Guénette & Doucet, 2017).

While financial numbers may not be encouraging, ridership and membership numbers have always been cause for optimism. BIXI represents a good example of a system which is both successful in terms of ridership and popularity, while also struggling in terms of management and finance (Faghih-Imani & al., 2014; Goodyear, n.d.; Messahel, 2016; Strini, n.d.). The system's rate of use has been increasing steadily since its beginning. Despite the financial problems and the bankruptcy of PBSC, the BIXI system has been available to users every summer, thanks to the City of Montreal who believed in the concept and the service (BIXI Montréal, 2017a; CBC News, 2014). Even when PBSC had difficulties balancing its revenues and expenses, the system's popularity continued to increase, and in 2012, the system had more than 49,000 members, and up to 25,000 trips were registered on peak days (Messahel, 2016). In 2016, the average number of trips per day was 21,000, 5,000 more than in 2014 (CBC News, 2017). In total, 4.1 million trips were made, 16% more than in 2015, and 39,710 memberships were sold, 11% more than the year before (Riga, 2016). Almost 235,000 riders used BIXI, which represented an 81% increase

compared to the numbers from 2014. The total number of passes and memberships increased by 159% for the same period, while purchases from occasional riders increased by 200%, reaching 398,650 passes in 2016 (BIXI Montréal, 2017a; Société Radio-Canada, 2017). The system also broke its own record on May 28, 2017, when 39,520 trips were registered on that day (Société Radio-Canada, 2017).

As a result, the system has contributed to changing behaviours. Indeed, before the launch of the system, only 25% of cycling trips were taken to go to work. Two years after the launch of the system, this number had increased to 53%. The system also garnered praise abroad. It won awards, and was named one of the best innovations of 2008 by Time Magazine (Tools of Change, 2013).

Some factors might have contributed to its popularity. Montreal has a good cycling culture and it is often described as a cycling city. In 2017, it was ranked 20th on the Copenhagenize's Bicycle Friendly Cities Index, and was the only North American city in that year's edition (Colville-Andersen, 2017). Montreal is the Canadian city with the highest numbers of daily cycling trips and segregated bike lanes.

The system also deployed different strategies to attract new customers. For instance, the name of the system, BIXI (contraction of the words "bicycle" and "taxi"), was decided through a contest which generated 8,896 different name ideas (BIXI Montréal, 2017c). The inauguration of the 375 new, colourful Montreal-themed bikes in 2017 also attracted the attention of media. The bikes are easily recognizable on the streets. BIXI Montréal also introduced in 2016 the event series BIXI Sundays ("Les Dimanches BIXI"). These allow people to ride a BIXI at no cost on the last Sunday of each month from May till October. In 2016, more than 134,000 rides were taken during all BIXI Sundays, bringing the total travelled distance during these days to around 400,000 km (Bérubé, 2017; BIXI Montréal, 2017a). The company also did surveys to define who its target audiences were, and it has used social media heavily as a way to reach younger generations (Tools of Change, 2013).

The company has also made marketing faux-pas when trying to attract new users. Between 2008 and 2009, the marketing company Morrow Communications created and produced content for a blog called "À vélo citoyens." Three cycling fans wrote articles and promoted cycling and the upcoming BIXI program. A Facebook group created by the three cycling aficionados attracted more than 1,300 followers. When it was revealed that the three individuals had been created by a marketing company and did not actually exist, some people, including residents and journalists, became angry and felt manipulated (Lagacé, 2009). BIXI has also made claims that it removes cars off the street. However, studies demonstrated that BIXI essentially replaces walking, cycling, and transit trips. Its

impact on the environment is therefore negligible since it does not replace car trips. BIXI Montréal has since changed its marketing approach to include more accurate facts (Bachand-Marleau, Larsen, & El-Geneidy, 2011; BIXI Montréal, 2017c; Guénette & Doucet, 2017; Société Radio-Canada, 2010).

The City's involvement in increasing the cycling infrastructure network certainly influenced BIXI ridership numbers in positive ways. Population density within the central areas of town, combined with a high density of stations, also helped to increase the use of the system. The presence of BIXI next to many metro stations has encouraged multimodal trips (Faghih-Imani et al., 2014). This may have helped to counterbalance factors that can act as deterrent to cycling, such as the climate. Indeed, winter is an important factor, since the bike-sharing system is closed and stored between November 15 and April 15, which limits opportunities to generate revenues. Montreal's intense variations in terms of climate also have an impact on people's propensity to bike (Faghih-Imani et al., 2014; Parc olympique de Montréal, 2015; Riga, 2016).

5.3. New York City's Citi Bike

5.3.1. Overview of the city

Located on the Eastern Atlantic coast of the United States, New York City is a cosmopolitan metropolis which has seen its population grow in the last 15 years, following several decades of stagnation or decline in terms of population growth. In 2016, the estimated population for the city was 8,550,405 inhabitants, an increase of 4.6% compared to 2010 numbers (World Population Review, 2017b). The metropolitan area has a population of 20,182,305 inhabitants, placing it second on the list of largest metropolises in North America, right behind Mexico City (WorldAtlas, 2017b). At 929 inhabitants per km², the New York – Newark – Jersey City, NY – NJ – PA metropolitan area has the second highest US metropolitan area population density, after Los Angeles – Long Beach – Anaheim metropolitan area (WorldAtlas, 2017a). The City of New York itself, meanwhile, beats all other cities in the country in terms of density, with 26,403 inhabitants per square mile. This last number is small compared to the population density in Manhattan, which reaches over 66,000 inhabitants per square mile (World Population Review, 2017b).

New York City's population is very diverse, in part due to its long immigration history. For instance, 44.6% of the population identify as white, 25.1% describe themselves as black or African-American, and 11.8% of the population declare having an Asian background. As for Hispanic people, they represent around 27.5% of the city's population. New York has a wide income disparity, with median annual household income ranging

from US$188,697 for a wealthy household to US$9,320 at the lower end. Meanwhile, the city has the highest number of millionaires and billionaires worldwide (World Population Review, 2017b).

Although it is located in a region which usually experiences a hot humid continental climate, New York City is characterized by a warm and temperate "humid subtropical" climate. As such, summers are hot, and humidity and precipitations are prevalent all year round (CantyMedia, 2017; Climate-Data.org, n.d.d). For instance, there are an average of 121 days per year of precipitations, with an annual average precipitation of 1174 mm distributed over the year. The city gets snow but large snowfalls are rare. New York City has an average of 2677 hours of sunshine annually, and the average temperature for the year is 12.85 ^{0}C, with high and low averages of 3.8 ^{0}C and -3.1 ^{0}C in January and 29.3 ^{0}C and 21 ^{0}C in July (US Climate Data, 2017a).

New York City is located on mostly flat and even land, and divided into five boroughs separated by waterways. Manhattan and Staten Island are islands, the Bronx is attached to the mainland, and Queens and Brooklyn are located on Long Island. All are connected through bridges, ferries and tunnels (NYC & Company, Inc., 2017). Located by the ocean, the city's elevations range from sea level to 125 m (U.S. Geological Survey, 2005).

5.3.2. NYC's bike-sharing system: main facts

City:	New York City, New York, USA
Name of bike-sharing system:	Citi Bike
Date of launch:	May 27, 2013
Owner/Promoter:	NYC Bike Share LLC, subsidiary of Alta Bicycle Share (now Motivate)
Operator:	NYC Bike Share LLC, subsidiary of Alta Bicycle Share (now Motivate)
Equipment provider:	First generation: PBSC; Subsequent generations: Motivate
Number of bikes & stations at launch (and now):	6,000 bikes at 332 stations (10,000 bikes at 610 stations)

Table 4. Citi Bike's main facts.

New York City's Citi Bike launched on May 27, 2013 with a fleet of 6,000 bikes distributed over 332 stations in Manhattan below 59th Street and some neighbourhoods in Brooklyn (Gastel & Tsang, 2014; Kaufman & O'Connell, 2017; Motivate International, Inc., 2017a; Sadik-Khan & Solomonow, 2016). In October 2014, a year and a half later, an

expansion plan was announced by the City of New York, Alta Bicycle Share, and Citibank. The plan proposed to double the fleet to 12,000 bikes and cover new areas by opening more dock stations (Gastel & Tsang, 2014). The expansion began in August 2015, two years after the initial start of the program, and as of August 2017, the system counts 10,000 bikes over 610 stations in 55 neighbourhoods across Manhattan, Brooklyn, Queens, and Jersey City. At the end of 2017, there should be 12,000 bikes distributed over 700 stations (Barone, 2017; Kaufman & O'Connell, 2017; Motivate International, Inc., 2017a & 2017d). This makes Citi Bike the largest system in the country (Motivate International, Inc., 2017a).

The system is owned by NYC Bike Share LLC (NYCBS), a company incorporated in 2011 and a subsidiary of Portland-based private company Alta Bicycle Share. NYCBS has been in charge of the system's operations, even after Alta was acquired by a group of private investors called Bikeshare Holdings LLC in October 2014 (Bloomberg L.P., 2017; Chaban, 2014; Gastel & Tsang, 2014; Haughney, 2011b; Motivate International, Inc., 2017a). Private investors included the CEOs of Equinox (fitness clubs) and Related Companies (real-estate) among others (Motivate, 2015). In the following year, a new CEO took over Alta Bicycle Share. Formerly the head of NYC's Metropolitan Transportation Authority, he consolidated and moved corporate headquarters from Portland, Oregon to NYC, and changed the name to Motivate (Bloomberg L.P., 2017; Chaban, 2014; Gastel & Tsang, 2014; Haughney, 2011b; Motivate International, Inc., 2017a). A service-level agreement was made between NYC's Department of Transportation and Alta Bicycle Share: If the operator fails to keep the stations clean and functional or to adequately maintain and keep the bikes in good working condition, it would be subject to fines from the City (ITDP, n.d.). Although Alta Bicycle Share/Motivate is the owner and operator of the system, the City has been extremely involved in the decision-making and implementation processes, including the location of the docking stations (Haughney, 2011b).

Motivate is also the current equipment provider. Indeed, while the system's first bike fleet was conceived by PBSC Urban Solutions, the new Citi Bike fleet is produced by Motivate, using plans prepared by a well-known Olympic racing bike designer (Beroud & Anaya, 2012; Fermino, 2015; Fried, 2015; Motivate, 2015; Motivate, n.d.; Ziegler, 2015). The first generation of Citi Bikes will be gradually phased out as new bikes are produced (Fermino, 2015). The equipment, software, and technology used by the system were also upgraded after 2014, and stations currently have touch screen kiosks (Bloomberg LP, 2017; Gastel & Tsang, 2014).

Figure 12. New York City's Citi Bike. Source: Siegel+Gale, 2016.

Citi Bike is privately subsidized, which makes it one of the rare systems in the US, with DECOBIKE San Diego, to rely entirely on private funds. The program relies on sponsorships and membership fees (Gastel & Tsang, 2014; Ogul, 2014). A large part of its funding comes from its title sponsor, Citibank, as well as Mastercard, the system's Preferred Payment Partner (Beroud & Anaya, 2012; Motivate International, Inc, 2017a). The system was successful in getting important sponsorships in part thanks to Janette Sadik-Khan, the City's former transportation commissioner, although Alta Bicycle Share was the entity officially responsible for finding sponsors. Sadik-Khan, who has many contacts amongst the "city's elite business circles," was very successful in fundraising and organising events to promote the system amongst potential donors (Haughney, 2011b; ITDP, n.d.).

Citigroup, owner of Citibank, initially invested a US$41 million loan in exchange for being lead sponsor for five years and obtaining naming and brandings rights. It later lent an extra US$15 million (Flegenheimer, 2012; Gastel & Tsang, 2014; ITDP, n.d.). As for Mastercard, it initially provided US$6.5 million over a five-year sponsorship period in exchange for being named the system's Preferred Payment Partner and having its logo put in highly visible places on the stations (ITDP, n.d.; Flegenheimer, 2012). In October 2014, the system received important sums of money in order to fund its expansion and improve its software technology. Bikeshare Holdings LLC, the new owner of Alta Bicycle Share, provided US$30 million of private capital. Moreover, Citibank increased its

sponsorship commitment up to US$70.5 million and extended it until 2024. Goldman Sachs Urban Investment Group also increased and extended its credit loan facility by US$15 million. The Partnership Fund for New York City, representing a coalition of business leaders, also invested US$5 million to fund "the program's growth into underserved communities in Brooklyn, Queens, and Upper Manhattan" (Flegenheimer, 2014; Gastel & Tsang, 2014; Kessler, 2015).

At the time when the City was still looking for an operator, it included a condition in the partnership contract requiring that profits on the venture would be shared with the City (Haughney, 2011b). While this is not the case *per se*, Alta's contract did stipulate that it would have to reimburse the City for revenue losses generated by the occupation of parking spaces by the system's dock stations (Melcher, 2014).

The first fleet of bikes, created by PBSC, had three gears like the ones in Montreal (Carlson, 2015; Haughney, 2011b). The stations are solar-powered and do not require excavation in the street, which was a condition imposed by the City when looking for an operator company.

Communities were involved in the decision-making process and contributed to the selection of locations for stations. For instance, an interactive map on the City's DOT website allowed citizens to suggest locations for potential Citi Bike stations in the city. The response was quick and hundreds of suggestions populated the map. (Gastel & Tsang, 2014; Haughney, 2011b). For the first phase of the project, the City adopted a "multi-year outreach process, which included over 400 meetings with Community Boards, elected officials, civic associations, property owners and community institutions" (Gastel & Tsang, 2014). This helped considerably during the site selection process, and the City adopted the same outreach approach again during the expansion phase (Gastel & Tsang, 2014).

5.3.3. Rates and use options

Compared to other cities' bike-share programs, NYC's Citi Bike rates are higher. When the system opened in 2013, it offered three options to consumers: annual memberships (including 45-minute rides) for US$95, day passes at US$9.95, and weekly passes at US$25 (both last options include 30-minute rides) (Chaban, 2014; Flegenheimer, 2012; Haughney, 2011b; Ogul, 2014). In 2014, the system was still struggling to be financially successful, and the organization, which was itself in a reorganization following the bankruptcy of Alta Bicycle Share, decided to change its fee structure in order to keep the program healthy following the expansion (Chaban, 2014; Gastel & Tsang, 2014; Ogul, 2014). The fact that the City of New York did not want to fund the project with public money also contributed to an increase in rates (Gastel & Tsang, 2014).

Annual memberships, still including unlimited 45-minute rides, increased from US$95 to US$149. To compensate for this price spike of almost 60%, Citi Bike announced that the company was examining new fare options like weekend, monthly, seasonal and tourist passes (Chaban, 2014; Gastel & Tsang, 2014). According to some articles, monthly and seasonal passes seemed more realistic, but in the end, no new types of passes were offered. (Chaban, 2014; Motivate International, Inc., 2017c). Weekly passes were replaced by 3-day passes. Prices have increased again: as of August 2017, day passes are US$12, 3-day passes are US$24, and annual membership are US$163. Day and 3-day passes include 30-minute rides, with every additional 15 minutes charged at US$4, while the annual card includes 45-minute rides plus a charge of US$2.50 for each additional 15 minutes (Motivate International, Inc., 2017c). This increase in rates was also justified in part by the absence of public funding from the City of New York (Gastel & Tsang, 2014).

The system has also offered several special rates and options for different groups. Citi cardholders are eligible to a 10% discount on the annual membership, which can be added to another promotion. Citi Bike has also created a Corporate Membership Program. Companies, universities, and apartment buildings enrolled in this program offer subsidized membership to their employees, students and residents. Members of the Oxford medical benefits plan can have Citi Bike memberships reimbursed by their plan since the bike-sharing program was added to the company's Sweat Equity Program, allowing members to get up to US$400 of fitness-related expenses reimbursed. (Motivate International, Inc., 2017c). It is interesting to note that the City of New York, which does not subsidize the system, does not subsidize the membership cost for its employees either (Kuntzman, 2017).

In order to make the system more affordable and therefore accessible to citizens with low- and moderate-income, discounted annual memberships, at an affordable rate of US$5 per month or US$60 per year, are available to NYC Housing Authority residents, as well as members of specific federal credit unions or Community Development Credit Unions (Gastel & Tsang, 2014; Motivate International, Inc., 2017c). Citi Bike customers also have access to coupons offering discounts on helmets which can be used in bike shops or with helmet designers (Bloomberg LP, 2017).

5.3.4. Successes and challenges

The system drew attention from the start, and the 5,000 founding memberships sold out in 30 hours in April 2013, weeks before the system's launch (Motivate International, Inc, 2017a). By opening day, the system had already 15,000 annual members. For the first seven days of operations, only these members were allowed to use Citi Bike (Sadik-Khan & Solomonow, 2016). One month after its opening, the system was

featured on the cover of The New Yorker magazine, and within seven weeks of activity, the system already totalled 1 million trips (Motivate International, Inc, 2017a; Sadik-Khan & Solomonow, 2016).

In May 2014, one year after its launch, the system had registered over 8.75 million trips for a total pedaled distance of more than 14.7 million miles (23.66 million km) (Carlson, 2015). The 10-million ride mark was reached just over a year after the start of the program, and in December 2015, the system announced it had reached its highest ridership number in one year, 10 million trips (City of New York, 2015; Motivate International, Inc., 2017a; Sadik-Khan & Solomonow, 2016). This put the system in second place in terms of bike share ridership in the Western Hemisphere, with Paris' Vélib' in first place. Citi Bike beat its own record the following year with a 40% increase in overall ridership, the system registering a total of 14 million trips in 2016 (NACTO, 2017a; Sugar, 2016). In 2016, it was not rare for the system to serve more than 60,000 trips in a single peak day (Sugar, 2016). A little bit more than a year after its first anniversary, the system's total distance travelled by users reached 20 million miles (32.1869 million km) (Motivate International, Inc, 2017a). In October 2014, more than 1 million Citi Bike trips were made every month, with an average of 40,000 people using the system every day from spring to fall. The system had sold more than 641,000 short-term passes, for a total of over 14 million trips and 25 million miles biked. (Gastel & Tsang, 2014). Within its first year of operation, Citi Bike saw more than 100,00 annual members sign up, and as of the end of July 2017, the system counted 312,011 annual members (Chaban, 2014; Gordon-Koven, 2014; Motivate International, Inc., 2017e). As Sadik-Khan explains: "we had to ask ourselves, for all the backlash and battles, had we built *enough* bike lanes to keep up with the hundreds of thousands of New Yorkers who were now getting around on bikes?" (Sadik-Khan & Solomonow, 2016).

This population was helped by the fact that NYC's streets changed radically during Mayor Bloomberg's tenure. Indeed, streets became much more pedestrian- and cyclist-friendly, and, between 2007 and 2011, 250 miles (402.3 km) of bike lanes were added (Haughney, 2011b). This number increased to more than 300 miles by the following year, and contributed to a boom in cycling of more than 400% compared to the decade preceding the implementation of Citi Bike (Sadik-Khan & Solomonow, 2016). At the end of the Bloomberg area, approximately 500 miles had been integrated to the cycling network (Kuntzman, 2017). This increase had even led some people to complain that "streets had now become overrun by people riding bikes" (Sadik-Khan & Solomonow, 2016). Streets are also much safer. For instance, between 2000 and 2013, a decrease of 72% in the average risk of serious injury was observed in the City of New York. The increase in cyclists also helped to make cycling safer in the city. (Hinds, 2013).

The system has always been considered very safe. In June 2017, the first Citi Bike rider was killed in a collision, the first death out of 43 million rides (Colon, 2017; Haag & Alani, 2017). The system's accident rate is very low, with about 10.5 crashes (with or without injuries) per 1 million trips (Goldberg, 2014). These low numbers can partly be explained by the fact that the bikes are "heavy, with a very low centre of gravity, wild tires, drum brakes that keep the braking system dry even in inclement weather … [and gears making it] difficult to gain considerable speed" (Goldberg, 2014). Rules of the road are displayed on the handlebars of every Citi Bike, and the City's Department of Transportation distributed bike helmets at events and promoted their use (Gastel & Tsang, 2014; Goldberg, 2014).

The expansion and funding increased the system's stability and operational capacity, while also providing more employment opportunities (and skills training) for local residents (Gastel & Tsang, 2014). It also allowed the system to reach low-income communities and neighbourhoods, which were underrepresented in the initial coverage of the system (Gastel & Tsang, 2014). Some of these, like Bedford-Stuyvesant, benefited from the involvement of local community-based organizations to support and encourage the use of the bike-sharing system by "largely minority residents" of the neighbourhood, with the additional aim of improving the health and other conditions of the local population (Katinas, 2017; Snow, 2017). In the case of Bedford-Stuyvesant, the partnership between the City, Alta Bicycle Share, city agencies, and local organizations and businesses was supported by an innovation grant and led to a 56% increase in Citi Bike memberships in this majority-Black neighbourhood (NACTO, 2017a; Rodriguez, 2017). Rides also increased by 225% between 2016 and June 2015, higher than the increase in overall ridership in the city for the same period, and active memberships in the area increased by more than 50% (Rodriguez, 2017; Snow, 2017).

The fact that the system launched with a large fleet and many stations, although not as numerous as initially planned, certainly helped the system take off. The location of stations were considered thoroughly and placed in different types of destinations, including residential areas, transport hubs and stops, as well as popular destinations. They also later included poorer neighbourhoods whose needs in terms of transportation options were greater (Snow, 2017). The system's launch was carefully planned. For instance, during the first week of operations, the number of users was limited to annual members who had registered before the system's opening. "The soft launch of about five thousand rides on that first day gave us a chance to work out the kinks while the city was emptied out for the holiday," explained Sadik-Khan (Sadik-Khan & Solomonow, 2016).

Politicians have also contributed to the bike-sharing discussion and tried to make it more accessible, for instance by introducing (several times, in 2014, 2015 and 2017) a

Bike to Work Act allowing workers to "use their pre-tax commuter benefits for bike sharing programs like Citi Bike," elevating the status of bike-sharing system as a transit option (Gastel & Tsang, 2014; Russell, 2017).

A study published in 2014 by New York University's Rudin Centre for Transportation showed that Citi Bike was used all year long, even during cold, snowy winter months by thousands of people, primarily commuters wishing to shorten their commute or to connect to other transportation modes. Their analysis pointed to the city's high urban density and stations' proximity to mass transit as being key ingredients to the system's large ridership numbers. The population size, mixed with the "tightly knit street grid" and the numerous connections to other modes of transportation, made it easy for people of all boroughs, even those living outside of Citi Bike covered territory and those commuting from the surrounding region, to access the system. It integrated within the transportation network (Gordon-Koven, 2014; Warerkar, 2017).

Struggles

Everything did not come easy for Citi Bike. For instance, the idea of implementing a bike-share system was first received with hesitation. The City had already been working on ambitious bicycle projects for a few years and therefore it was not easy for City officials to get a green light for this other important initiative (Haughney, 2011b). Several times, City officials feared the project wouldn't survive (Sadik-Khan & Solomonow, 2016).

The program was initially planned to start in April 2012, but delays pushed the launching date several times up to May 2013. Delays were due to software glitches and a long search for sponsors (Chaban, 2014; Haughney, 2011a; Seaton, 2012). While 10,000 bikes were supposed to be available right from the start, the initial fleet was reduced to 6,000 bikes (Flegenheimer, 2012). This was caused by Hurricane Sandy, which damaged 1,000 bikes and 90 stations stored in the Brooklyn Navy Yard and delayed the launch of the program by a year. The program also lost US$5 million after the hurricane, when half of the US$10 million of damage it suffered could not be reimbursed because of bureaucratic mistakes, which led to legal action (Chaban, 2014; Flegenheimer, 2012 & 2014; Kessler, 2015). When the system finally launched, it still had problems with software glitches and management, but the City administration, whose electoral term was rapidly coming to an end, had to launch the program despite these issues, to avoid the risk of seeing the project die with the next administration (Flegenheimer, 2014).

One of the biggest challenges the bike-share program had to face were issues regarding its equipment and management. At the time of the launch, there were widespread concerns regarding the system itself, which still had many bugs. There were also complaints from locals who found the stations "ugly and arbitrarily placed in

neighbourhoods." (Sadik-Khan & Solomonow, 2016). The locations of the stations provoked outcry from citizens who feared accidents and "rogue riders" (Chaban, 2014). There was also doubt that the system would be able to attract local residents (Flegenheimer, 2014).

Janette Sadik-Khan confirmed that the system's new software had issues, and that at the time of launching, it could take the system several seconds, up to half a minute, to unlock a bike after swiping a user's key. In her book *Streetfight,* she explains: "We were smiling in front of hundreds of media, drenched in brilliant sunlight for Citi Bike's launch, but inside I was afraid the entire system might crash" (Sadik-Khan & Solomonow, 2016). At some point, stations failed to release a bike around 10% of the time (Austen, 2015). These difficulties continued during the following months, with stations' batteries dying, and stations not being connected to credit card and communications systems, meaning credit card readers would not work (Flegenheimer, 2014; Fleischer, 2014). Despite the frustrations, the system's popularity continued to rise, thus increasing the pressure to improve the system (Chaban, 2014; Sadik-Khan & Solomonow, 2016). For instance, the first generation of Citi Bikes were allegedly fragile and hard to repair or maintained, which led to a lower number of accessible bikes and frequently empty dock stations (Ziegler, 2015). Flat tires, broken gears, and cracked seats were common, to the point that in 2014, almost one-third (between 1,200 and 1,900 bikes out of a fleet of 6,000) of Citi Bikes were stored in a warehouse waiting to be repaired (Fasick, Mongelli & Fears, 2014). This high need for maintenance, which was in part a result of the system's success and its constantly high ridership levels, added to the already steep bill. On the other hand, the number of tourists using daily passes was lower than expected (Flegenheimer, 2014; Kessler, 2015). The system was banking on them to increase revenues. Though more annual memberships were bought than expected, there were fewer short-term pass sales than predicted, putting the system in in financial trouble (Kessler, 2015). On top of these issues, PBSC, the supplier of the equipment, "filed for bankruptcy protection in January 2014" (Flegenheimer, 2014). The software problems led to an increase in operating costs, because of the need to dispatch technicians and hire new employees at a call centre to treat the numerous complaints (Flegenhiemer, 2014).

This, combined with the "glitch-filled" system, negatively affected the riders' trust in the system, even though ridership stayed high (Chaban, 2014; Ziegler, 2015). As the current chief executive of Motivate, Jay Walder, explained in 2014: "It's extraordinary how quickly Citi Bike has become a part of the fabric of our city, and what's even more remarkable is that this has happened despite the frustrations we all feel with the system" (Chaban, 2014). Following the restructuration of Alta Bicycle Share, the system's equipment was revised, and the company implemented new software and an app, which

tracked users' trips. The company replaced old kiosks, repaired or replaced 12,000 docking points, and overhauled bicycles with new design elements produced by Motivate itself to increase the fleet and its quality. The bike had better gears, seats, and quickstand (Budin, 2015; Chaban, 2014; Fermino, 2015 Kessler, 2015; Ziegler, 2015). One year later, customer service calls had diminished by almost half, and there had been a reduction of 80% of the time spent by technicians at stations to fix problems (Kessler, 2015).

In addition, management issues caused many problems to the system. In 2014, before Alta Bicycle Share was reorganized, the company was close to bankruptcy. It had been criticized for being disconnected from the program and its supporters. Customer service was heavily criticized, while the system's app, although accurate, was not functional nor fully reliable. NYC Bicycle Share also had a hard time rebalancing the system's fleet and keeping up with bike repairs and maintenance. For instance, its repair facilities operated only 5 days a week, and would accumulate a backlog of bikes over the weekend. Moreover, all bikes needing repairs were brought to the facilities, instead of enabling technicians to make small repairs on the spot. The stations' batteries were not monitored, which meant that the company waited until a station malfunctioned or stopped working before intervening. Station inspections were not performed either, and the company did not adequately treat complaints regarding cleanliness, as indicated by a 2014 audit of the system. The system kept falling behind which came to the point of provoking a conflict with the city (Flegenheimer, 2014; Fleischer, 2014; Kessler, 2015). While most of these problems were corrected after the restructuring of the company and the situation is better now, the company still owes the City of New York US$1 million for lost parking revenues due to the presence of docking stations on parking spaces (Kessler, 2015; Kuntzman, 2017).

Again, Sadik-Khan recounted the situation during the first few months of the program: "I knew that some of the hardest days lay ahead, as the fabulously popular new transportation mode collided with its own still-buggy software and lackluster private management and funding. … the remaining days would be an ordeal to keep the program from collapsing and rescue it from the self-inflicted wounds or its own management" (Sadik-Khan & Solomonow, 2016).

The system has also suffered from constantly evolving ridership (Kuntzman, 2017). While membership levels have been overall increasing since the beginning of the program, they have also fluctuated drastically. For instance, between May 2014 and July 2014 – when annual memberships had to be renewed for people who had registered at the launch of the system, the number of memberships dropped from 105,359 to 93,501 (Goldberg, 2014; Kessler, 2015). More recently, the system has been facing fresh criticism, especially regarding the size of the bike fleet that cannot match the demand. As a result,

dock stations are often empty at rush hour and users struggle to find a bike, making the program stall according to some critics (Kuntzman, 2017; Tangel & Hufford, 2016). On the other hand, users also complain that stations are sometimes completely full, requiring them to spend time looking for a parking spot. Since the system is already saturated, there is no upcoming plan for a third phase of the bike-sharing system which would reach Staten Island and the Bronx, two boroughs which have yet to see stations on their territory (Kuntzman, 2017). As of May 2017, negotiations started between the City's Department of Transportation and Citi Bike officials regarding a possible expansion into these two boroughs, although no timetable currently exists for this project. Discussions centered on finding ways to make the expansion a reality without using municipal funds. Citi Bike asked the City to reconsider the fee for lost parking revenue they are charged every year to compensate for lost revenues due to the implementation of a station on a parking space (Walker, 2017). The system is in need of growth to accommodate the increasing needs of the population, but as Kuntzman summarized in June 2017, the system is currently "on hold, stymied by lazy politicians, expensive infrastructure, stubborn community leaders, outdated fealty to car culture, and a rejection of competition from innovative new dockless systems that are dying to fill the CitiBike vacuum. … Since CitiBike has a monopoly on service, it should function like a utility such as tap water or electricity. But it sometimes lets me down" (Kuntzman, 2017).

The cycling scheme operator has had some issues with Community Boards regarding the installation of new stations, and while more money would allow the system to grow, the current de Blasio administration is not as much of a supporter of cycling and bike-sharing than the previous administration. Many have been looking at new dockless systems to see if their emergence, backed by venture capital money, might eventually impact Citi Bike, a system whose docking stations and technology make the system costly, compared to a dockless, app technology-based system.

Regarding equity and accessibility, the increase in membership fees raised concerns from political officials and the public when it was first announced, although the maintaining of memberships discounts to NYCHA residents and other citizens in need contributed to keeping the system accessible to those with lower incomes (Gastel & Tsang, 2014). That said, 83% of Citi Bike trips have an origin and destination within Manhattan, and "only 18% of stations are located in ZIP codes where median household incomes are less than $50,000" (Rodriguez, 2017).

5.4. Seattle's Pronto!

5.4.1. Overview of the city

Seattle is the largest city in the American state of Washington. Located in the northwestern part of the country, it had an estimated population of 659,000 people in 2014 (World Population Reference, 2017d). As for the metropolitan area, it contains a population of 3,733,580 inhabitants, making it the 20th largest metropolitan region in North America, right after Montreal (WorldAtlas, 2017b). It also represents more than half of the state's population (World Population Reference, 2017d).

Compared to the other case studies, Seattle's population is less diverse when it comes to race and ethnicity. It is one of the whitest large cities in the country, with 69.5% of its population being white, and 66.3% being white with no Hispanic background. That being said, the city's population diversity has been growing, and for instance, the percentage of people identifying as white in the city dropped from 91.6% to 66.5% between 1960 and 2010. The number of residents born outside of the USA has also increased by 40% in ten years. Asians represent 13.8% of the population, African-Americans count for 7.9% of the population, and those identifying as Hispanic or Latino represent just 6.6% of the population. Seattle is home to a large LGBT community, with 12.9% of its population identifying as such, which represents one of the highest per capita in the United States. People aged 25-35 years old are also the most numerous within the city, with considerably smaller groups of citizens aged below 20 years old (World Population Reference, 2017b).

The city has been experiencing a population boom over the last ten years, having the 14th biggest population increase in the country, and it is expected that the metropolitan area will grow by 1.7 million people by 2040. This has led to housing problems within the area (World Population Reference, 2017b).

Seattle is famous for its rainy and warm temperate climate. While summers are warm and dry, winters are quite rainy and the city has an average of 147 days per year with precipitation or rainfall, mostly from October to May (CantyMedia, 2017; Climate-Data.org, n.d.c; US Climate Data, 2017c). Snow is rare. The city counts on an average of 2163 hours of sunshine per year, with summer receiving up to 6 times more sunshine hours than during the winter months. The average for annual precipitation and rainfall reaches 943 mm. While the annual average temperature is 11.5 ^{0}C, the city's temperatures fluctuate from high and low averages of 7.6 ^{0}C and 2 ^{0}C in December to 24.6 ^{0}C and 13.3 ^{0}C in August (US Climate Data, 2017c).

Seattle lies on and around a series of hills, lakes and rivers between two mountain ranges. Its elevation ranges from sea level to 159 m (Advameg, Inc., 2017; American Association of Geographers, n.d.; U.S. Geographic Survey, 2005).

5.4.2. Seattle's bike-sharing system: main facts

City:	Seattle, Washington, USA
Name of bike-sharing system:	Pronto!
Date of launch:	October 13, 2014
Owner/Promoter:	Puget Sound Bike Share (then City of Seattle)
Operator:	Alta Bicycle Share (now Motivate)
Equipment provider:	Arcade Cycles
Number of bikes & stations at launch (and at moment of shutting down):	500 bikes at 50 stations (500 at 54 stations)

Table 5. Pronto!'s main facts.

Seattle's Pronto! system was launched on October 13, 2014, with 500 bikes and 50 stations throughout the downtown and a few central neighbourhoods (Herz, 2014, Yuan, 2014). Expansion projects were envisioned right from the beginning by the city's administration, and the city Council had been asked by the Mayor to approve a budget of US$600,000 from taxpayer money to implement the system to lower-income areas in the summer of 2015 (Chen & Guerrero, 2014; DeLuca, 2014). The system was operated by Alta Bicycle Share (now Motivate) and owned by Puget Sound Bike Share, a public-private, non-profit partnership led by local transportation and transit agency representatives and corporate sponsors (Beekman, 2016; DeLuca, 2014; Fucoloro, 2014). Funding for the program included grants from King County and the City of Seattle, as well as private financing from corporate sponsors (Trujillo, 2014). State and federal grants reached an amount of US$1.75 million (Associated Press, 2017; Gutman, 2017b). Alaska Airlines was the main private sponsor and was supposed to contribute US$2.5 million over 5 years (US$1,000 per bike per year over 5 years) to support the system in exchange for having their branding on the first 500 bikes. Other sponsors included Seattle Children's Hospital, Group Health Cooperative (which sponsored 15 stations), Vulcan Inc., REI, Fred Hutchison Cancer Research Centre and Spectrum Development Solutions. User fees were expected to cover the remaining operating expenses (Donner, 2014; Fucoloro, 2014; Soper, 2016).

Every station had a helmet bin providing helmets for users, since the Emerald City is located in the King County where a mandatory-helmet law has been implemented on the whole territory since 2003 (DeLuca, 2014; Gutman, 2016; Herz, 2014; Washington State

Department of Transportation, 2017). It is interesting to note that the state of Washington does not have a state law requiring helmet use, but many cities and districts, including King County, do have a mandatory-helmet law (Washington State Department of Transportation, 2017). According to it, cyclists biking without a helmet are subject to a fine of US$102 (Giddings, 2017; Gutman, 2016). Pronto! was the first bike-share system in the US to distribute helmets to its users (DeLuca, 2014, Trujillo 2014). The initial plan was to have helmet-vending kiosks at each station selling or renting helmets at a rental cost of US$2 (Fucoloro, 2014). In the end, helmets were offered for free during the first months following the honor system (Cohen, 2017; DeLuca, 2014, Trujillo 2014). In 2015, vending machines were installed to dispense helmets for a fee, after more and more helmets stopped being returned. The cost was US$2 a day for non-members, while annual members had access to the service for free (Carlson, 2015; Chen & Guerrero, 2014; Cohen, 2017; Gutman, 2016; Machkovech, 2017). Each helmet was wrapped in a sealed plastic bag and could be checked out once a bike was unlocked (Chen & Guerrero, 2014; Yuan, 2014). Users were expected and trusted to return used helmets in a separate section of the bin at a docking station. Used helmets were then collected, inspected and cleaned (with soap and then sprayed with sanitizer) before being made accessible for reuse by new users (Chen & Guerrero, 2014; DeLuca, 2014; Gutman, 2016; Trujillo, 2014).

Figure 13. Pronto! system, with the helmet-vending machine at the front. Source: Soper, 2014.

Figure 14. Pronto!'s helmets. Source: Yuan, 2014.T

The system had a smartphone app associated to it, called Spotcycle (Herz, 2014). The custom bikes were manufactured by French company Arcade Cycles, and were said to be lighter than other bicycle models used in similar bike-sharing system in the US (Trujillo, 2014). They had seven speeds "set at a Seattle-hills-ready gear ratio" and a pedal-powered headlight (Fucoloro, 2014). As for the stations, they were solar-powered (Carlson, 2015; DeLuca, 2014, Trujillo 2014). The reason behind the selection of Arcade Cycles' bikes instead of the models usually used at the time by other Alta Bicycle Share systems was the fact that PBSC, the company supplying the other bikes like Washington DC's Capital Bikeshare, went bankrupt earlier that year, before a business deal was concluded with them. Pronto! was the first system to rely on a new business arrangement between the operator Alta Bicycle Share, 8D Technologies (in charge of the system's hardware and software technology) and bike manufacturer Arcade Cycles (Fucoloro, 2014).

The public was involved in the decision-making process regarding the locations of the stations. Several community planning workshops were organized in May and June 2014 (Fucoloro, 2014).

5.4.3. Rates and use options

Pronto! only had a few options for users in terms of rates. It offered an annual membership at a starting price of US$85, a day pass at US$8 and a three-day pass at US$16. The first 30 minutes of each trip taken during the duration of the membership or the pass

were free. Overtime fees were US$2 for rides between 30 and 60 minutes, and US$7 for rides of 60 to 90 minutes. Each additional period of 30 minutes would be charged an extra US$5, while rides of more than 8 hours would be charged US$77. After a bike was borrowed for more than 24 hours, it was considered missing or stolen and the user would be charged US$1,200 (Beekman, 2016; Herz, 2014; Yuan, 2014). This was done in order to incite people to use the system for utilitarian purposes and not as an all-day rental. Users could use either their credit card or a membership key fob to pay and unlock a bike (Yuan, 2014).

5.4.4. Successes and challenges

The first few days did not necessarily indicate a failure of the system. Some small issues were mentioned, like small technological problems on social media and helmets feeling too tight to some users. Otherwise, nothing predicted a possible failure. The program had avoided the PBSC bankruptcy saga, unlike Citi Bike and BIXI (Fucoloro, 2014). On its first day of operations, 314 rides were completed (Herz, 2014). Moreover, Seattle is considered a hub for cycling culture and communities, with a large affluent and outdoorsy population (DeLuca, 2014; McFarland, 2017; Small, 2017). The Emerald City was ranked by the magazine Bicycling in 2014 as the 8th best city for cycling in the US, just behind San Francisco and before flatter cities such as Boston and Cambridge (DeLuca, 2014). In 2016, *Cycling* ranked the city at 5th in its list of bike-friendliest cities in the country (Small, 2017).

Unfortunately, ridership numbers and subsequent revenues ended up being much lower than expectations, which led to budget deficits. Within its first year, the system registered 142,846 rides and 3,000 members. This was much lower than the projected 446,000 rides and 4,000 members (Beekman, 2016; Robertson, 2017). As a comparison, Capital Bikeshare in Washington, D.C. registered over 1 million rides during its first year of operation, for a system comprising 116 stations and 1,100 bikes at the time, and it had 18,000 members (Small, 2017). Small comfort: the 33,000 casual rides in the first year beat the projections of 20,500 rides (Robertson, 2017). The total revenue from users during the first year turned out to be US$613,000, much lower than the projected US$860,000 (Robertson, 2017).

Even City of Seattle employees, who had access to subsidized memberships at US$35, did not respond to the call. In the following months, ridership and membership numbers kept decreasing, with April 2016 seeing a decrease of 30% in ridership compared to the previous year (Golliver, 2016; Lloyd, 2017d). Data from Pronto! for its first year of operation revealed that bikes were used on average less than once per day (0.78 trips per bike per day) (Cohen, 2017; Robertson, 2017; Snow, 2017; Soper, 2016). This is below the

national average of 1.8 rides per bike-sharing bike per day (Cohen, 2017). In comparison, Pronto! data mention 11,960 trips per month for the system, compared to 51,061 for Minneapolis' Nice Ride Minnesota, 245,607 for Capital Bikeshare in Washington D.C. and 204,027 for Chicago's Divvy (Soper, 2016).

In January 2016, the system was deemed insolvent, partly due to "high overhead costs and debt service on money borrowed to buy equipment" (Beekman, 2016). The fact that a third party was in charge of the operations was seem as a cause for overhead costs, while borrowing costs were the result of insufficient funds to buy the equipment. Operating losses created a US$1.2 million debt (Small, 2017; Soper, 2016). Puget Sound Bike Share had estimated that memberships and user fees would be able to cover 3/4 of the operating costs in the first year, while the remaining quarter would be funded through sponsorship. Initial corporate sponsorship funds, as well as state and federal funds, would be dedicated to the system launch phase only. Unfortunately, low levels of rides and memberships led to much smaller user revenues to cover operating costs.

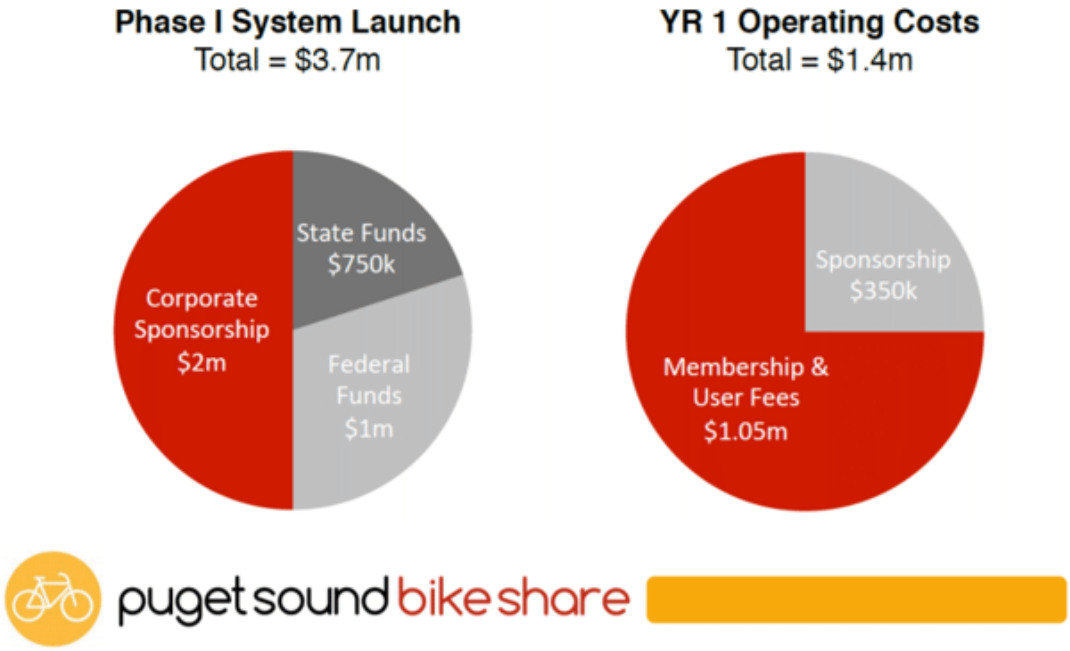

Figure 15. Budget estimates for Pronto!, done by PSBS, 2014. Source: Small, 2017.

Moreover, the non-profit that owned the system stopped raising funds a few months before the purchase by the City, when they knew that a possible takeover from the City was on the table (Beekman, 2016; Small, 2017). However, they thought the City would acquire the system earlier than it did, and therefore when the City bought it, the program was in a very bad financial position (Cohen, 2017; Small, 2017). The timing coincided with the failure of the City's Department of Transportation (DOT) to obtain a US$10 million federal TIGER transport grant to expand the system (Small, 2017). The City,

who previously wanted to invest US$5 million to expand the system, saw its plans changed when confronted to the financial issues of the system (Dornfeld, 2016; Soper, 2016).

In order to save the system from shutting down, the City Council voted to buy the program from owner Puget Sound Bike Share for US$1.4 million on March 15, 2016. This amount was used to acquire the system and pay off its debts (Beekman, 2016; Cohen, 2017; Dornfeld, 2016; Soper, 2016). An additional US$305,000 was paid without being disclosed for weeks by the DOT and served to cover operating costs while Motivate was still operating the system (Robertson, 2017).

The option of buying the system was preferred to that of looking for a new public-private partnership (Beekman, 2016; Cohen, 2017; Dornfeld, 2016; Soper, 2016). The decision had also been supported by other stakeholders such as the Cascade Bicycle Club and Seattle Neighbourhood Greenways (Cohen, 2017). The purchase was made by the DOT, which planned on expanding the then 54-station system to other neighbourhoods in 2017 and adding electric bikes. The plan was to extend the system to 1,000 bikes, between 70 and 130 stations, and to increase the amount of memberships to 8,000 (Beekman, 2016; Golliver, 2016; Gutman, 2016; Soper, 2016). By doubling the number of stations, the City aimed at increasing the system's scope and resolving density problems, while electric bikes would address the problems linked to the city's hills (Gutman, 2016). This approach, according to a DOT analysis, would have tripled the number of trips and doubled the revenue coming from users (Small, 2017). The City hoped to have more control on the functioning of the program, and agreed to an expansion of the system on the conditions that the Council have more oversight on it, that the expansion allow a better service to "low-income populations and communities of color," and that downtown Seattle's bike-lane projects be completed before the system be expanded. Another condition included that the new bike-share operator would be appointed by the Mayor and Council to avoid potential conflict of interest, since the Director of Seattle's DOT was a former president of Alta Bicycle Share (The Associated Press, 2016; Beekman, 2016; Dornfeld, 2016; Small, 2017; Soper, 2016). The Director was eventually investigated and fined US$10,000 for an ethics violation regarding the Pronto! project (Cohen, 2017; Gutman, 2017b; Robertson, 2017).

In the weeks following the purchase of Pronto! by the City, annual memberships were sold at a discounted rate of US$63, and the first 45 minutes of each ride were made free for annual members, instead of the usual 30-minute period. Less-performing stations were also moved to other locations with the hope of generating more rides (Golliver, 2016).

In spite of these efforts, the system continued to struggle. A tender process to find a new contractor for the system was organized to put the program back on track, with main proposals all calling for a complete refreshment of the system including an update of equipment to new stations and bikes. The winning bid went in September 2016 to Quebec company Bewegen (one of the descendents of former company Public Bike System Company – PBSC, or *Société de Vélo en Libre-Service – SVLS,* which went bankrupt in 2014), whose proposal included the replacement of the actual fleet for an electric-assisted set of bikes (Beekman & Lee, 2017; Cohen, 2017; Schmitt, 2017b). However, the new contractor also faced challenges, having never managed a project of that magnitude. In November 2016, the City was negotiating with Bewegen regarding the purchase of 1,200 electric-assisted bikes and 100 new docking stations, which would have constituted for the company a bigger order than all its other bike orders combined (Beekman & Lee, 2017; Gutman, 2016). The replacement of the fleet would have also required the City to renegotiate the sponsorship it had from Alaska Airlines or to find additional sponsors (Small, 2017).

In late 2016, following intense negotiations, a budget of US$5 million was agreed upon to revamp and increase the system while also acquiring pedelecs. This funding was conditional on approval by City Council of the final plan provided by Bewegen in January 2017. However, the plan and budget felt through. The failure of the City to obtain a US$10 million federal TIGER transport grant to expand the system did not help the cause (Cohen, 2017; Snow, 2017). It became more and more difficult to campaign for the expansion of the system amongst the political sphere (Small, 2017). Finally, the Mayor of Seattle – who was running for re-election in 2017 – decided to shut the system down instead of expanding it (Beekman & Lee, 2017). In November 2016, a budget approved by the City Council projected the end of the system, and the news was made official on January 13, 2017. US$3 million of the funds aimed at the expansion was redirected towards bike and pedestrian infrastructure in downtown as well as for a Safe Routes to School program (Barber, 2017; Cohen, 2017; Macz, 2017; Office of the Mayor, 2017; Small, 2017). The decision itself to close the system was apparently taken by the Mayor's office without consultation with other Council members, including those who had been working on the expansion of the system (Packer, 2017). Despite of this decision, the Mayor declared to "remain optimistic about the future of bike-share in Seattle" (Office of the Mayor, 2017). He added that the next system should aim at benefiting residents from all areas in town (Macz, 2017).

On March 31, 2017, the system was officially shut down. The equipment was put in storage while awaiting to be sold to other cities (Gutman, 2017b; Lloyd, 2017d; City of Seattle, 2017b). Users whose memberships still had several months remaining received a refund for the period of their contract following March 31, while non-members and riders

with expired membership were offered the opportunity to buy a special membership for US$10 until the closure of the system (Gutman, 2017b; Lloyd, 2017d; Robertson, 2017).

Interestingly, soon after the shutdown of Pronto!, a few private dockless bike-sharing companies became interested in implementing their system in the Emerald City (Rietmulder, 2017). In June 2017, three competing companies were discussing with the City of Seattle to plan launches of their systems: Asian Bluegogo, whose plans have been put on hold since then, and Bay Area-based LimeBike and Spin (Alicea, 2017; Lloyd, 2017e & 2017f). While the first one had extensive experience overseas, LimeBike had only implemented small systems like on a university campus and only in the weeks preceding its arrival in Seattle. As for Spin, it had previously had a trial launch in Austin, Texas, and Seattle would serve as its first permanent system (Associated Press, 2017, Gutman, 2017a). More than 10 different companies, including some with only electric bikes, demonstrated interest at some point in implementing a dockless system in Seattle (Demay, 2017; Lloyd, 2017a).

Faced with this large interest, the City of Seattle changed rules for bike-sharing systems in late June 2017, and in July 2017 it put into place a pilot program with a licensing framework in order to regulate private cycling scheme companies. It is set to last from July until December 2017, before being evaluated by the City who will determine if it can be officialized as a permanent program (City of Seattle, 2017a; Lloyd, 2017c and 2017d). The City will also examine the propensity of people to carry a helmet with them (Demay, 2017). Through the pilot program and its permits, the City of Seattle will get revenues as companies must pay modest fees of around US$9,300 for the first 500 bikes, followed by US$15 for each additional bike beyond the initial 500. Companies also have to provide the municipality with data regarding the number and locations of the rides (Gutman, 2017a; McFarland, 2017). This regulatory framework is regarded as being the first of its kind within the country, and the permit process was chosen over the selection of a specific company because it was fast and allowed for massive time savings comparatively to a Request for Proposals process, which usually takes several months. It also allowed having more bikes on the ground than if only one company had been selected. Additionally, competition between the different companies should ensure high service quality within all of them in order to attract users (Lloyd. 2017a).

Regulations apply to the companies' operations, safety, and parking rules, as well as the size of their fleets. For instance, companies must apply for a permit and have it approved before launching their systems (City of Seattle, 2017a; Lloyd, 2017a & 2017f). Also, companies are allowed to have fleets of maximum 500 bikes on the ground during the first month of the pilot program. They will be allowed to increase that amount to 1,000 bikes during the second month of the pilot, and then to 2,000 in the third month of the

pilot (Lloyd, 2017f; McFarland, 2017). At 2,000 bikes, the companies will be asked to respond to some minimal geographic equity standards, such as making sure to include Tier 1 Priority Hire areas that correspond to economically-distressed ZIP codes in 20% of their service area. These areas include most of downtown Seattle (Lloyd, 2017a & 2017f). Starting in the fall 2017, licenced companies that have complied with all criteria will not be restrained anymore in terms of fleet size, and they will have the right to extend their program to the size that they wish (Gutman, 2017a; Lloyd, 2017c). Both LimeBike and Spin hope to expand their fleet, with Spin aiming to have 10,000 bikes throughout the city (Land, 2017). If the pilot goes well, the systems should be able to deploy their fleet of 10,000 bikes in the city street by the end of 2017 (Kroman, 2017).

Companies are not required to provide helmets to users, as long as they remind users that the helmets are required by law (Demay, 2017; Lloyd, 2017f). This regulation shows some flexibility from the government, as the mandatory-helmet law allows entities to rent bikes only if the renter has a helmet (Demay, 2017). So far, LimeBike has been distributing 1,000 free helmets to new users at promotional events and street fairs, but otherwise, no dockless systems plans on providing helmets with the bikes (Bishop, 2017; Demay, 2017; Gutman, 2017a). This takes out a financial burden that the Pronto! system had to deal with. Moreover, the Seattle Police Departement reacted to the situation by declaring that it would let its officers use their discretion and decide whether they want to enforce the mandatory-helmet law. They could, for instance, only write a citation or provide a warning and explain the laws. (Kroman, 2017).

The pilot project also touches on the dockless bike-share issue of broken or unsafe bikes. In order to avoid the abandonment of broken bikes in the streets as seen in Asia, the City requires companies to remove unsafe or inoperable bikes within 24 hours of notice, otherwise the Department of Transportation will remove them and charge the companies for the expense (Lloyd, 2017f).

On July 17, 2017, Spin launched its system in Seattle, placing its bikes on the streets in the downtown area. It was the first bike-share company to launch its program since the death of Pronto! and the company indicated an interest in expanding its territory to other neighbourhoods and eventually all of them, a goal that will be facilitated through an increase of its fleet size (Associate Press, 2017; Kroman, 2017; Lloyd, 2017f). The program did not have a specific limited territory, as they preferred to analyze the origins and destinations of the first users before setting boundaries and adjusting the scale of their deployment. They were also looking at questions of social equity, recognizing that the system relies heavily on smartphones and credit cards and that lower-income populations may not always have access to these (Lloyd, 2017f). LimeBike addressed this issue in August 2017 when they rolled out cash payments not requiring smartphones or credit

cards. Instead, users can go to the company's Seattle office and load up their account with cash. After that, users can call LimeBike at any time to unlock a bike anywhere in the city (Lloyd, 2017b).

LimeBike, who had its permit approved the same day as Spin, implemented their bikes outside during the subsequent days (Lloyd, 2017f). Its bikes were built specifically for Seattle's environment and terrain (Lloyd, 2017e). As of August 11, 2017, returns for both companies had been very good, with LimeBike claiming that their first week of operations was more successful than Pronto!'s best week. That being said, the companies have also had to adjust. For instance, Spin had to add lower gears on its bikes in order for them to be adequate for the city's hills (Kroman, 2017). The fleet has also been the target of vandalism, which has caused some issues, and customers have reported technological bugs with the software, geolocalization system, or the app, as well as problems relating to the bikes themselves (Bishop, 2017; Kroman, 2017). For instance, some bikes have been taken inside private locations by users where the bicycles are not accessible to other users despite being officially available (Bishop, 2017).

Other dockless bike-share companies have also initiated a process to implement their system in Seattle (Kroman, 2017). Beijing-based ofo applied for an operating permit during the second week of August and was approved a few days later. The company launched its system on August 17, 2017, with a rate of US$1 for one hour (Lloyd, 2017c; McFarland, 2017). As of mid-August 2017, Dallas-based Vbikes had applied for the operational permit in order to launch its system in the city (Kroman, 2017; Lloyd, 2017e). Another company, Koloni Share, has demonstrated official interest in launching its system in the city (Gutman, 2017a). This system is characterized by the fact that bikes can be parked at "geofenced hubs" (Lloyd, 2017e).

A big difference between Pronto! and these private companies, beside the fact that they are dockless, is the fact that they do not require public funding (Alicea, 2017; McFarland, 2017). For instance, both LimeBike and Spin are "funded with millions of dollars of venture-capital money" (Associated Press, 2017). Also, their pricing structure (US$1 for a 30-minute ride) makes the systems more accessible and flexible from a financial point of view (Bishop, 2017). LimeBike also offers monthly packages of 100 rides at US$29.95 and students are entitled to a 50% discount on both monthly and basic rates, making the system even more attractive (LimeBike, 2017; New Mobility Group, 2017). These for-profit companies might also rely on publicity through their app to increase their revenues (Gutman, 2017a).

The fact that they do not have stations also led the City to select authorized locations where the bikes can be left. These include mostly "the landscape-and-furniture

zone of the parking lot between main pedestrian thoroughfare and the curb, with some exceptions" (Lloyd, 2017f), (i.e. the zone of the sidewalk next to the street, where one can usually find trees, parking meters and bike racks) (Gutman, 2017a) as well as "any public sidewalk or city bike rack, as long as [the bikes] aren't blocking driveways, entryways, bus stops and the like" (Land, 2017). Grassy zones, as well as sidewalk corners, are prohibited areas (Gutman, 2017a). This provides more flexibility to people when it comes to picking up or dropping off a bike (Kroman, 2017). As for bikes parked incorrectly, the operator will have 2 hours to place it in an authorized location between 6am and 6pm, and the timeframe is increased to 10 hours outside of business hours (Lloyd, 2017a).

These dockless systems may prove to be more adapted to cities with a hilly topography like Seattle (Lloyd, 2017a). Companies will also have redistribution teams working towards a better distribution of the bikes on the territory if needed (Gutman, 2017a). The pilot program will allow the City to evaluate whether an increased amount of bikes will be enough to diminish the accessibility issues within the City, or if electric bikes – or a combination of both factors – are a more realistic approach to face the city's hilly terrain (Lloyd, 2017a).

One concern raised of private dockless systems is the quality of the bikes and the often poor maintenance of the fleet. Spin's co-founder reassured people that this would not be the case as they hope people will use their bikes in order to make more revenue. As well, the pilot program will allow the City to determine if bike overcrowding turns out to be a large issue (Lloyd, 2017e). The pilot program will also allow the City to monitor the maintenance of the equipment, the balancing of the system throughout the territory, as well as the compliance of the system with public policy goals (Lloyd, 2017a).

But what made Pronto! fail? Some people pointed out the city's hilly topography and rainy weather, which are not conducive to utilitarian cycling (Beekman, 2016; Snow, 2017). Data showed that only 35% of rides had their point of origin located at a lower elevation than their point of destination, demonstrating that the majority of trips were going downhill (Giddings, 2017).

Other suspected factors include the mandatory-helmet law, which can discourage and cut potential ridership (especially spontaneous casual trips) and use of a bike-sharing system by half, according to bike-sharing expert Paul DeMaio (Barber, 2017; Gutman, 2016; Small, 2017; Snow, 2017). Indeed, bike helmets can "hurt the spontaneity that makes bike share successful" (Cohen, 2017). This impacts in return the perception of safety, since there are less cyclists on the road (Gutman, 2016; Snow, 2017). That being said, City officials explained that surveys done by the operator tended to demonstrate that the helmet law was not a limiting factor, and that the helmet-distribution system was working

well. (Cohen, 2017; Gutman, 2016) Others argued that the helmet law's effect is so important than even expanding the network or adding pedelecs would not have overcame the ridership problem (Gutman, 2016).

Pronto! also started very small compared to other systems and it ignored low-income neighbourhoods which have greater needs in terms of transportation options. These points could have been important factors according to DeMaio (Snow, 2017). The system was also very spread-out, with a low density of stations and kiosks being spread in non-contiguous areas. This is important, considering that to be successful a system is recommended by some experts to have 20 to 28 stations per square mile, while Seattle only had around 12 stations for the same area. The lack and delay in the system's expansion therefore impacted negatively the success of the scheme (Cohen, 2017; Kroman, 2017; Schmitt, 2017b; Small, 2017). Experts argued that a better integration between the cycling scheme and the public transport network – especially the expanding light-rail system, under-construction bus rapid transit, and streetcars – could have been beneficial to the system (Cohen, 2017). The city also lacked an attractive and safe cycling network to bring more people in the streets and increase the perception of safety (Cohen, 2017; Gutman, 2017b; Snow, 2017).

Critics have mentioned the loss of political support within and outside the municipal government as being a factor, leading up to the rejection of the system by the Mayor itself (Cohen, 2017; Small, 2017). While cycling advocates and politicians were quite supportive of the system at the beginning, their allegiance started to waver when the municipality began considering the purchase of the insolvent system following its first year of operations. Support continued to decrease following the system's purchase and the investigation of one of the main decision-makers in the acquisition process. The decision to replace the existent equipment for a new one constituted another source of frustration and tensions, some Council members disagreeing with the expenditure. All this generated poor media coverage for the project, which snowballed into negative public perception. The negative coverage of the system, which started during the first year according to some experts, contributed to diminishing support among the political and community scenes (Cohen, 2017; Small, 2017). Mismanagement was also mentioned as negatively impacting the system's outcomes (Small, 2017).

5.5. DECOBIKE San Diego

5.5.1. Overview of the city

San Diego is a city located in Southern California, just North of the Mexican-American border. Its population is estimated at 1.339 million inhabitants in the city of San Diego itself, while the metropolitan area holds 3,299,521 inhabitants in 2013 (WorldAtlas, 2017b; World Population Review, 2017c). The San Diego-Carlsbad metropolitan area occupies the 20th rank in terms of population density within the US, with 295 inhabitants per square meter (WorldAtlas, 2017a). Within the city frontiers, the density is of 4,003 inhabitants per square mile (World Population Review, 2017c).

The city's population is very diverse and multiethnic. Demographic information dating from the 2010 census show that 15.9% of San Diego's inhabitants identify as Asian or with an Asian background, 6.7% are African-American, 45.3% are white with no Hispanic background, and 28.8% have a Hispanic or Latino background, with a majority coming from Mexico (24.9% of the Latino/Hispanic population) (World Population Review, 2017c). The city is home to a wide contrast in terms of social inequalities. It was ranked as the fifth wealthiest city in the country by Forbes in 2005, while also having the third largest homeless population and around 15% of its population living below the poverty line in 2005 (World Population Review, 2017c).

The population has been growing in the last few years, with more immigrants moving to the city. This tendency is expected to continue. Projections set the city's population at 1.9 million by 2050, an increase of 49% compared to 2000 numbers. Also, according to projections, the Hispanic population will surpass the white population in terms of numbers in 2035, while the white population's size will start decreasing by that same year. The current population is relatively young, with more people aged 20-30 years old than any other age range (World Population Review, 2017c). The median age is 34.9 years old, and 25% of the population is 20 years old or less, compared to 12% of the residents aged 65 and above (City of San Diego, 2017).

In terms of weather, the city enjoys a semi-arid (steppe) climate characterized by dry summers and arid winters ranging from hot to cold (CantyMedia, 2017; Climate-Data.org, n.d.b). Temperature does not fluctuate much over the year, with an annual average high temperature of 20.9 ^{0}C and an annual average low temperature of 14.2 ^{0}C (annual average of 17.6 ^{0}C). It rains on average 43 days a year, for an average annual precipitation/rainfall of 264mm. It also receives a lot of sun (2958 annual hours of sunshine) and absolutely no snowfalls (US Climate Data, 2017b).

The geography of the city is characterized by flat sea-level plains and, to its northeast and northwest, 120-meter-high "mesas", or table-topped hill with a flat top and steep cliffs around it (Marshall, n.d.). The city has around 200 urban canyons, many of which are undeveloped or partly developed due to their "steep hillsides and rushing streams during winter storms" (San Diego Canyonlands, Inc., 2012). Urban areas concentrate mostly on the plains and on the flat top of mesas (San Diego Canyonlands, Inc., 2012). Since the city is built around a bay and the ocean, its elevation ranges from sea level to 251m (U.S. Geological Survey, 2005).

5.5.2. San Diego's bike-sharing system: main facts

City:	San Diego, California, USA
Name of bike-sharing system:	DECOBIKE San Diego
Date of launch:	January 2015
Owner/Promoter:	DECOBIKE, LLC. (in partnership with the City)
Operator:	DECOBIKE, LLC. (in partnership with the City)
Equipment provider:	-
Number of bikes/stations at start (and now):	1,000 bikes at more than 100 stations (1,800 at 180 stations)

Table 6. DECOBIKE San Diego's main facts.

Following the City of San Diego's 2013 Bicycle Master Plan, DECOBIKE San Diego was launched in January 2015 with 1,000 custom bikes distributed over more than 100 solar-powered automated stations (Garrick, 2015; DECOBIKE, LLC., n.d.; San Diego County Grand Jury, 2016). As of August 1, 2017, the system had reached its initial goal of providing 1,800 bikes at 180 stations. The system was implemented by Miami-based firm DECOBIKE, LLC., in a corporate partnership agreement with the City of San Diego. The firm is also in charge the operations and maintenance. The system is non-subsidized by the government, a decision based on the city's consistently mild climate which allows for revenue earning all year long. Instead, the program is funded through user fees, sponsorships, and advertising (on the station's advertising panels and through apps, social media, and promotional material) (DECOBIKE, LLC., n.d.; Garrick, 2015; Garrick, 2016; Ogul, 2014; San Diego County Grand Jury, 2016). DECOBIKE signed a 10-year contract with the City of San Diego in 2013, investing more than US$8 million to provide and install equipment like bicycles and dock stations (Garrick, 2015, Lozano, 2015; Schwab, 2014). In exchange for its official partnership with the City of San Diego, DECOBIKE agreed to share part of its profits with the City for a minimum of US$1 million over the first 10 years of the contract (US$25,000 in the first year, and a minimum of

US$175,000 per year for the subsequent 10 years) (Ogul, 2014; Schwab, 2016a; The San Diego Union-Tribune Editorial Board, 2016). As for the City, they allowed DECOBIKE to install ad panels at kiosks and on bikes in order to generate revenues from the sale of ad space (Hargrove, 2016; Schwab, 2016a).

Stations are mostly located in central areas of the city, as well as popular and touristy spots like beaches, downtown, and the harbour (Hargrove, 2016). This has an impact not only for the users, but also in terms of advertisement, since panels are located in valuable high-demand areas like Ocean Beach and La Jolla (DECOBIKE, LLC., n.d; Schwab, 2016b).

Figure 16. DECOBIKE San Diego's station on a boardwalk in Pacific Beach.
Source: San Diego Community News Group, 2015.

5.5.3. Rates and use options

DECOBIKE San Diego can be used in two ways: as a bike-sharing system requiring membership or as an hourly bike rental. In the first scenario, members have the option of getting a standard membership with unlimited 30-minute rides, or a deluxe membership with unlimited 60-minute rides. The standard membership costs US$20 per month, or US$125 annually. The deluxe membership is offered at a cost of US$199 per year or US$30 per month. In order to attract users at the beginning of the program, the first 1,500 members had access to a promotional annual rate of US$99, and received free helmets (DECOBIKE, LLC., n.d.).

In order to have access to the monthly rates, a 3-month minimum commitment is necessary. In case of early termination, cancellation fees are applied. The program also proposes short-term memberships of a month or less to accommodate seasonal visitors. These short-term rentals are only available online, and they propose two prices: US$35 for a week, and US$50 for a month. After the end of the rental period, users are charged US$5 for each additional 30-minute period. To gain access to the bikes and the membership benefits, members rely either on a membership key or their credit card (DECOBIKE, LLC., n.d.).

The second type of program is based on hourly rentals. With this option, users do not need to bring the bikes back to a station after 30 or 60 minutes: they are free to ride and may keep the bike for the duration of the rental period. They can ride any bike from any station, for the amount of time desired, or dock a bike at any station and check-out a different one, as long as it occurs during the rental period, which starts once the original transaction is made. For this option, users use their credit cards to access the bikes and stations. Prices for hourly rental vary from US$5 for a half hour to US$7 for an hour and US$12 for 2 hours. Past the rental session, users are charged US$5 for each additional 30 minutes of use (DECOBIKE, LLC., n.d.).

5.5.4. Successes and challenges

The bike-sharing system has faced many challenges from its inception. The launch of the program was delayed several times – more than a year of delays – due to different issues, such as manufacturing and disagreements regarding the location of some docking stations (Ogul, 2014, San Diego County Grand Jury, 2016; Schwab, 2016b).

The system has also attracted fewer users than other similar systems (Ogul, 2014). For instance, in its first year of operation, 102,641 individual rides and 697 memberships were sold. In comparison, in New York, almost 4 million rides and more than 85,000 memberships were sold within the first three months of operations of Citi Bike in the summer of 2013 (Schwab, 2016a; The San Diego Union-Tribune Editorial Board, 2016). Moreover, most rides were taken from tourist locations, while many kiosks aimed at commuters registered small amount of rides (Garrick, 2016). Most of the system's rental revenues were generated by casual, short-term rentals (San Diego County Grand Jury, 2016). This seems to indicate that the system might be more popular with tourists than locals (Garrick, 2016). This does not advance the City's Climate Action Plan goal of increasing "the number of people bicycling to work in the city's densely populated neighborhoods … from about 2 percent to 6 percent by 2020 and then to 18 percent by 2035" (Garrick, 2016; Trageser, 2016).

These low numbers might be due in part to its pricing structure, since DECOBIKE's rates are significantly higher than other schemes' prices (Ogul, 2014). This is due in part to its lack of subsidies from local governments, as well as the fact that the system operates year-round compared to other cities that stop operating in cold winters. At the time of the launch, daily access fees to the system were set at US$15, which was more expensive than in a lot of other American cities such as New York (US$10 in 2014), Washington (US$7, now US$8) or Minneapolis (US$6). Similarly, San Diego's annual membership fee of US$125 (which has been unchanged since 2015) is much higher than that of other cities like Washington (US$75 in 2014, now US$85) and Minneapolis (US$65 in 2014, now US$75) (Motivate International, Inc., 2017b; Nice Ride Minnesota, 2017b; Ogul, 2014; San Diego County Grand Jury, 2016). Since the launch of the system, the scheme's business model has changed and daily access fees were removed from the list of rental options. The hourly flat rate differentiates San Diego's system from others, and has proven to be successful (DECOBIKE, LLC, n.d.; Ogul, 2014).

Low usage can also be related to the fact that the operator encountered resistance from some property owners and neighborhood advocacy groups about station locations, making it more difficult for the operator to reach its goal of 180 stations (Garrick, 2015; Ogul, 2014). The process was also made more difficult by the multiple factors and requests at stake when it came to the docking stations. Therefore, the system operated with a low number of stations during several months (85 stations in August 2015) (Garrick, 2015, Schawb, 2014).

The implementation was heavily criticized (Garrick, 2015). The system received harsh criticism from bike advocacy groups and community leaders after the company decided not to put stations in lower-income areas of town. Some groups deplored the situation, explaining that many stations are located on public land, and therefore all residents should benefit from it. This situation can be partly explained by the fact that low-income areas, as well as less populous neighbourhoods usually generate less profits (Ogul, 2014). Critics argued that the non-subsidized system's stations were specifically installed on lucrative locations with high tourist traffic (like beaches) instead of focusing on commuters, responding to the population's needs, or attracting car drivers (Garrick, 2015; Ogul,2014). The operator did not deny the fact that stations were located to be as visible as possible in order to generate high ridership (Garrick, 2016).

Others criticized the lack of transparency from DECOBIKE and the City in the decision-making process and scheduling of station locations, as well as the absence of bicycle infrastructure in many areas where the scheme's stations were installed (Garrick, 2015; Ogul, 2014; Schwab, 2016a). Some planning committees also complained that none of their advice was taken into account in the selection of station locations. In fact, some

stations were installed in places where the community had specifically raised objections, for instance a crowded boardwalk in Pacific Beach (Garrick, 2015; Lozano, 2015; Schwab, 2016b). Such situations created frustration amongst local residents, especially near beaches (Schwab, 2016b), and popular petitions were even distributed by community activists (Schwab, 2016a). Concerns were also raised regarding the ads put on the stations, many residents complained that the stations were an eyesore (Garrick, 2016; San Diego County Grand Jury, 2016). Other groups criticized the operator's and City's unwillingness to discuss these issues. For instance, DECOBIKE waited a long time before talking with community groups and other stakeholders, and then stopped communicating after it received objections about the station locations (Garrick, 2015; Schwab, 2014). The operator denied these accusations, arguing that community groups were heavily consulted, and several other factors were considered in order to choose the locations of the stations (Garrick, 2015). Community meetings that were organized by the operator and the City were often seen as disorganized and unfocused (Lozano, 2015). The company subsequently expressed its desire to improve community outreach in order to reduce protests. For instance, the City notified property owners of the upcoming installation of the stations, but did not notify tenants, leaving local merchants and residents in the dark about the system. (Garrick, 2016). A report published in May 2016 by the San Diego County Grand Jury recommended the City be more supportive and consistent when it came to the cycling scheme, as well as to assign one official spokesperson as the contact person and official promotional advocate for the bike-sharing program at the City-level (San Diego County Grand Jury, 2016).

Tensions also occurred with the local transit agency. The San Diego County Grand Jury 2016 report affirmed that the Metropolitan Transit System officials had been "uncooperative" by not allowing bike-sharing stations near important bus and trolley stations, which is a key factor in using cycling schemes as a first/last mile solution. The transit agency defended itself by stating that it cooperated with the operator, but that many of its stations were too narrow to accommodate a station without posing safety and accessibility issues. They added that for some specific hubs, they proposed alternative location to proposals from DECOBIKE, but had seen their proposals ignored by the company (Hargrove, 2016; San Diego County Grand Jury, 2016; Trageser, 2016).

Another criticism levied against DECOBIKE is the fact that it provided new competition for bike rental businesses in tourist areas like Pacific and Mission Beaches. Groups called out DECOBIKE'S unfair advantage, since the scheme's stations were placed on municipal land at no cost and created direct competition to bike shops located in the area (Garrick, 2014, Schwab, 2016b). For example, the owner of four bike rental businesses in Mission Beach claimed to have lost US$60,000 in sales in one year due to DECOBIKE.

These claims are backed by a report showing that 77% of DECOBIKE's rides during its first year were made for recreational purposes, operating in competition with local rental shops (Schwab, 2016b). This situation led some community activists to describe the program as not being subsidized by the City, but by local bike rental shop owners (Schwarb, 2016a). The situation was minimized by the San Diego County Grand Jury report published in 2016, which argued that bike-sharing systems operated differently than bike rental shops, and therefore did not compete directly against each other. The report also mentioned that no bike rental shop had shown proof of income loss (Hargrove, 2016; San Diego County Grand Jury, 2016).

Finally, the program encountered logistical problems: 80% of the first 85 stations had to be moved from their original location (The San Diego Union-Tribune Editorial Board, 2016). One of the reasons was that the stations were located in shaded spots or were facing east and west, meaning that they received too little sun exposure to run the solar-powered kiosks (Lozano, 2015). Some other stations had to be relocated because they did not attract enough customers or received too many complaints from nearby businesses or residents (The San Diego Union-Tribune Editorial Board, 2016).

CHAPTER 6:
ANALYSIS AND DISCUSSION

All four case studies, whether considered successful or not, have experienced important struggles throughout their relatively short lives, and no case is an example of a perfect bike-sharing system, implementation and operations. Some factors and themes have come up frequently throughout the cases to explain the struggles or successes of the systems. In this section, we will compare these elements and the way they were approached in each case.

6.1. Types, business and financing models of a public transportation service

All four models have struggled with financial issues. Considering that fourth-generation bike-sharing systems are relatively new in North America, it is not surprising for cities and companies to encounter financial hurdles along the way, large or small. In hindsight, we can see that bike-sharing systems in North America have been adopting a trial and error approach. Today, in 2017, we have a better idea of the difficulties related to cycling schemes when it comes to revenues and profitability.

As with other public transportation services, breaking even is challenging and systems must rely on important external sums of money in order to prevent debt. Revenues generated by user fees are rarely sufficient to cover capital and operational costs, even less so to make profits. Few systems are financially efficient in North America. In Europe, some systems like Paris' Vélib' are working well because their system is managed by an advertising company with large sums of capital.

In the case of San Diego and New York City, both municipal governments decided not to invest public money in their system. Besides this similarity, both systems are very different due to the methods and approaches adopted by the cities and operator companies. In the case of San Diego, the private company DECOBIKE relies heavily on user fees to fund the system. This has led to issues related to the location of stations and, even more problematic, to the mandate and goal of the cycling scheme itself. Since the system needs money to survive, stations were placed where they could generate high ridership and revenues, and not where they would accommodate commuters. Therefore, stations have been mostly implemented in very busy and touristic areas like beaches and downtown, leaving behind residential neighbourhoods, transportation hubs for commuters and lower-income communities. This has led residents to complain that stations' locations favoured the for-profit operator rather than the public. For instance, some stations take space in very popular and touristy spots, while also creating unfair competition with bike rental shops (especially since the system offers hourly rentals, acting like a real bike shop with unlimited opening hours). Because DECOBIKE San Diego

only makes revenues through user fees and advertising on kiosks and bikes, it had to implement high rates for its system, making it less affordable and accessible than other systems. The system's annual membership cost of US$125 is a lot compared to other systems which are also operating year-long. Moreover, the City of San Diego requires the operator to share its profits with the City, taking away money that could be used to make the system more efficient or more adapted to residents' commuting and utilitarian patterns.

In New York City, Citi Bike relied mostly on sponsorships to survive, concluding deals of several million dollars with banks and other wealthy businesses or individuals. That being said, this was still not sufficient to make the system profitable or to allow for a publicly-requested expansion. Therefore, the system's rates were raised considerably in order to increase the system's efficiency and size. For instance, the annual membership price increased from US$95 in 2013 to US$163 in 2017. Even if the program offers discounts to allow low-income people to have access to the service at a lower cost, it can still represent a considerable expense for medium-income people, who might prefer to buy a bike for the same price as an annual pass, for instance. As of summer 2017, it is becoming more and more obvious that to continue its expansion and better serve the public, the system would need either more sponsorships or public funds.

Seattle's Pronto! and Montreal's BIXI cases are different in many ways, but ultimately, they both heavily depended on their City's subsidies, one surviving thanks to it and the other closing last March after Seattle pulled the plug. BIXI's plan for breaking even did not work because PBSC had not accurately anticipated the operational costs of the system. Their choice of creating a company which would act both as an operator and as an equipment provider and business did not produce the expected outcomes, in part because of the company's lack of expertise in some fields, such as software technology or call center services. What seemed like a good idea at first (having a business branch making money to fund the public transportation service) turned out to be a complicated and controversial situation. The provincial government was not fond of a City-made for-profit company selling its products to other cities (even if it was to fund its non-profit branch). Moreover, when the business branch started to have problems with its clients, it added to the financial and logistical problems that the system was already experiencing through its operational branch. In the end, the City of Montreal had to invest tens of millions of dollars (CAN$60 millions in 10 years) in order to save the operational branch of the company, and it had to sell the business part for a very low sum of money in order to get rid of it. Thankfully, the system was saved without having to increase rates astronomically or to stop the system's operations for a time during the regular season.

In the case of Pronto!, the system received subsidies from different government levels, but were small compared to other systems like Citi Bike. The City of Seattle invested a lot of money in the project throughout the years, but the system never got enough funding to realise a well-needed expansion. Therefore, the system continued to be unprofitable, and when it became clear that much more investment would be needed from different levels of government, which was a challenging task, the City decided to close the program, thus losing most of the money it had invested since the bike-sharing system's debuts.

Having a city run a bike-sharing program by itself can prove tricky, since the responsible governmental entity might be lacking the expertise to make the system as efficient as possible. This happened in Montreal. On the other hand, having a specialized private operator company is not a guarantee of success, as shown by the three other cases. Motivate, which is one of the biggest bike-sharing operating companies in North America and runs some of the most efficient systems on the continent like Washington, D.C.'s Capital Bikeshare, was in charge of Seattle's Pronto! The operator's expertise did not prevent the system from collapsing. It is also in charge of Citi Bike, and in that case, while the company's previous operational and administrative structures proved problematic for the efficiency of the system, ultimately, it is the funding of the system, combined with a restructuring of the company, which allowed the system to grow and improve.

In the end, Montreal and New York City's systems' popularity contributed greatly to their survival, but they also created problems, since the systems could not manage their growth and quickly lacked funds to respond to the growing demand (Kessler, 2015). On the other hand, Seattle and San Diego never had great ridership numbers. While in the case of San Diego, it has not put the system in jeopardy, in the case of Pronto!, it led to its death.

The emergence of dockless bike-sharing systems and start-ups merit closer attention as they will most likely compete with all our case study systems in the near future, having already replaced Pronto! in Seattle. These new smart systems offer a different service that can be seen either as a competition or as a complement to public bike-share systems. Their costs are much lower, which is a clear advantage considering that finances have proven to be one of the biggest issues faced by systems in North America. The absence of stations makes these programs more flexible, which is convenient, especially for cities whose system's expansion is limited. However, the lack of experience and the trial/error approach of most dockless system start-ups cannot ensure that these companies will be more successful than their predecessors in the long run. Even if their systems are less expensive to operate, user fees are much lower as well. Some operating costs like bike redistribution will have to be covered, whether the systems are

dockless or not. Some systems have also experienced problems with the GPS localization of the bicycles, theft, vandalism, and bike breakdowns. Issues and conflicts regarding bike parking in public space can also arise. Finally, competition between the different start-ups might produce negative outcomes and impact some systems' performances. For instance, in Seattle, there were three start-ups launching their systems in the city towards the end of summer 2017. Time will tell if there is a market for three companies, and if the systems will end up competing or complementing each other. It will also allow the City of Seattle to see if the lack of expansion of its defunct Pronto! was the real problem behind its lack of ridership, or if the mandatory bike helmet law or the city's hilly geography could have been a major factor as well. The City has also put regulations to restrict the activities of these new start-ups, and over the next months, it will see if these are adequate or if other adjustments are needed to make the systems profitable while also being in the best interest of the population and users. Since this phenomenon is very recent, it is still too early to tell what the impacts of dockless system start-ups will be on the bike-sharing field, but they will certainly transform the game.

The perception that municipalities have of their bike-sharing systems seems to greatly influence their destiny. In Montreal, the City sees BIXI as a public transportation service, and like transit systems, the City has chosen to subsidize it in order to make it accessible to its residents. It is not profitable, though public transportation systems rarely are. The City of New York chose to not provide public funds towards its bike-share scheme, but instead it got deeply involved in the funding process for the program, especially at the beginning. That said, as of 2017, the need for a new expansion and for an increase in the system's services to meet the demand bring some experts to say that the City might eventually have to agree on subsidizing the system, as other funding options might not be sufficient or become rarer. Otherwise, the system will become less and less reliable, and it will face a situation similar to 2014, when its fleet and services could no longer meet the growing demand. In Seattle, the City chose to close the system and turn to private start-up companies to fill the vacuum. Time will tell if this new offer can adequately respond to the still-undefined demand. Finally, in San Diego, the system turned out to be more of a rental bike business than a service for commuters and utilitarian cyclists, showing some disparities between the program's expected goals and on-site reality. This has caused frustration amongst the population, which does not approve of the fact that the City provided free spaces for a system that does not seem to serve the local public's interest.

6.2. Logistical and technological issues: trials and errors

On top of financial and structural issues, some systems encountered logistical problems which impacted their efficiency and reputation. For instance, DECOBIKE San Diego had to relocate most of its stations after putting them in places where they would not get enough sun exposure. This added to the already growing frustration of the population regarding the location of the stations and the decisions made by the private company DECOBIKE. It illustrated well the company's lack of experience and the system's reputation suffered from it.

Citi Bike also suffered considerably from its operator's logistical issues. For instance, around the time the operator was going through restructuring, the system started to generate lots of frustration from users due to the lack of reliability of the system. Very often, stations were either completely full, or either completely empty. This was due in part by the lack of efficiency in bicycle distribution, and to the poor maintenance and repairs of the bike fleet. It was revealed that bikes were not being repaired during the weekend, leading to constantly growing piles of bikes to repair. Bikes with small repairs were brought to the maintenance facilities instead of being quickly repaired on the spot, station inspections were not done and kiosk's batteries were not being checked until they would malfunction or stop working. Combined with the population's growing demand, this made the system less and less efficient, until changes were brought to the company's structural and operational strategies, and bikes were added to accommodate users' growing needs.

The system also suffered from its provider PBSC's errors. Indeed, the provider's bad decision of changing its equipment's software led to major functioning problems within some of its clients' systems, including Citi Bike. These technological problems, combined with other logistical and financial problems from the side of PBSC, caused many delays in the instauration of the system, and it also undermined the City and population's confidence in the system. In the case of New York City, the City got stuck in a situation that it could not prevent, as it did not know about the provider's new plans until it was too late to change. When it comes to Seattle, the City's decision to allow new dockless bike-sharing start-ups on its territory might open the door to some new problems since the systems have not been widely tested beforehand. As in a trial/error process, the systems might encounter technological bugs and logistical or operational problems which might take some time to fix. This might require patience and indulgence from Seattle's users while the problems are being resolved. However, considering the residents just came out of a two-year-and-a-half saga with their previous bike-sharing system, which

demanded a lot of their patience already, it will be interesting to see if they still follow the new systems or not.

6.3. Favouring ridership

There are a few factors which get experts' consensus in terms of being beneficial for the success of a bike-sharing systems. Having stations located near public transit hubs and stops is one of them. Both popular systems BIXI and Citi Bike have several of their stations located near transit hubs, and these stations often register the higher numbers in terms of ridership. Inter-modality was seen as a key factor in the popularity of both systems, allowing people from neighbourhoods where the systems are not implemented to still have access to it easily. The other two cases, which were much less popular, did not put inter-modality as one of their system's prime goals. As a result, locals did not often use the system since it was not convenient or relevant to their commuting trips.

Creating partnerships with other transportation-related agencies or companies can also help to attract more users. For instance, BIXI and car-sharing organization Communauto created a partnership in order for their members to have access to discounts. Since studies on the system showed that BIXI users were mostly using public transit for their trips before switching to cycling, it makes sense to reach a company like Communauto whose users do not have a car and, therefore, are within the same group than most BIXI users. The operator also concluded partnerships with other companies targeting similar audience to that of BIXI, such as car2go and Téo Taxi.

Starting big, with a cohesive and dense network, was also seen as a good method of attracting ridership. While Montreal and New York started with thousands of bikes and hundreds of stations covering a decent area size, the other two systems implemented much smaller systems, both in terms of equipment and in coverage size. This did not attract enough users to allow for a further expansion towards other areas. The systems were condemned to find money elsewhere if they wanted to expand beyond their initial size goal. This never happened for Pronto!, while DECOBIKE took a few years to reach its initial goal of 1,800 bikes at 180 stations, and encountered a lot of resistance from the local population regarding its stations' locations. BIXI and Citi Bike, on the other hand, had a lot of stations from the start, allowing people to reach many more destinations on a much bigger territory. This attracted a lot more customers, and the systems were able to generate more revenues. The presence of more cyclists in the streets also increased safety due to the "safety in number" phenomenon, and this in turn contributed to attracting more people to cycling and using the system. This created a snowball effect, where the

increasing number of users created a demand for an even bigger system, which then attracted even more users.

The two east-coast metropolises have also invested heavily towards the building of a cycling infrastructure network in the past decade. Combined with the fact that the systems' bicycles are heavy and not made to go fast, this has contributed to creating a more inviting and safer environment for cyclists to ride, therefore increasing the appeal of bike-sharing systems in these cities. In contrast, Seattle and San Diego do not have good cycling infrastructure network, and no effort has been made in the past years to change the situation.

Accessibility to the system is also an important factor, and although low-income citizens are not the ones most using bike-sharing, making the system affordable demonstrates a commitment from a City and/or operator to make bike-sharing a public service for the population's well-being. Montreal and New York City's systems have a lot of different rental options for users, and Citi Bike have discounts for its low-income residents. BIXI offers rates for groups or people wanting to share a membership, for instance. Although Pronto! had affordable rates, it did not propose many options for its customers, and DECOBIKE San Diego's options besides its expensive annual memberships were more adapted for tourists and recreational cycling than for commuting cycling purposes. These two last systems also did not implement stations in low-income areas due to their lower profitability. Knowing that low-income residents are usually those that would benefit the most from a larger choice of transportation mode options, it becomes evident that these systems' main goals were linked to profitability rather than the improvement of residents' transportation options and quality of life.

6.4. Inclusion of citizens in the process

One of the biggest criticisms received by San Diego's DECOBIKE was the lack of transparency and consultation with the different stakeholders. Community groups and planning committees complained that the operator did not listen to their advice or did not consult the population before implementing their system. According to them, DECOBIKE started involving communities late in the process and stopped including them as soon as complaints were raised regarding the location of the station. The community and outreach meetings which were organized by the City and the operator were seen as disorganized, and for many, it was too little, too late. The City was also criticized by community leaders for not listening to citizens' claims and not providing the population with enough details about the system. For instance, by reaching only building owners and not tenants, the information regarding the system did not reach a big percentage of the local residents

affected by the project. The City's involvement in the project, like in the selection of locations, was also not completely transparent, and a report from the San Diego County's Grand Jury criticized the inconsistent involvement of the City in the project and required it to be more supportive of the program and more organized. DECOBIKE also had issues with the local transit agency, accusing it of not cooperating on the project by allowing stations to be put at transit hubs and stops. The agency refuted the accusation, saying that they proposed alternative locations for places where a station could not be installed, but that their suggestions were ignored by the operator.

These examples represent how important it is for a company to do public outreach and get all stakeholders involved in the implementation of a bike-sharing system, at the risk of being heavily criticized and see its projects condemned or unsupported by the local population. DECOBIKE seemed to have prioritized its revenues ahead of the population's benefits, ignoring the population's will when it came to the location of kiosks and not considering other options for locations that raised concerns. Since the system's survival is based on its ridership numbers and revenues, it makes sense that the for-profit company sticks to more lucrative locations in order to make more money. But this enters in direct conflict with the main purpose of a bike-sharing system, to offer new commuting opportunities for local residents. By ignoring citizens, the operator run afoul of the population which increased the system's unpopularity.

In the case of BIXI and Citi Bike, the population's interest was better taken into account. For instance, before implementing its BIXI system, PBSC did a survey to better understand who its target audience was, where its potential users were located and what were their activities. This helped to choose locations for the stations and led the company to rely more on social media in order to reach young generations. In New York, communities and residents were involved from the start of the project. Citizens were invited to make suggestions for potential Citi Bike stations on an online interactive map. The City met with several stakeholders like Community Boards, elected officials, as well as local residents, groups and associations. It also partnered with some community groups to successfully encourage bike-sharing within low-income sectors. This involvement remained present even after a change of administration, as well as during the second phase of expansion, proving a constant care for the city's residents. This helped to get the population's approval and support for the project, and most likely contributed to the success of the program.

6.5. Political and cultural matters

Political support has also been a key factor in the success or failure of the four case studies. In the case of New York and Montreal, the Cities were involved from the start and never gave up their support. Even if the City of New York has refused to use public funds to subsidize the system, the administration was extremely committed to the project and has strongly contributed towards its realization and survival. Even if Alta Bicycle Share was the one in charge of finding the sponsorships, the City made major efforts into creating partnerships that would lead to considerable funding. The Bloomberg administration also decided to start the program despite the system's glitches to ensure that it would be running already when the new administration would take over a few months later. Their commitment towards the project and its impact on communities was amongst the main reasons the program has been successful and is still running today.

In the case of Montreal, the survival of the program strictly depended on political support, and without the administration's decision to save the system, there would probably be no BIXI in Montreal today. The City has been injecting money in the system since its beginning and is ready to continue to do so just as it does with other public transportation services. This vision will allow the system to survive despite not being profitable.

Political support was also fundamental for Seattle's Pronto!, since a big part of its initial and subsequent funding came from the government. However, the system started to lose its support from political and advocacy groups when the City started to consider using public funds to acquire and save the system. Support declined even further when it was revealed that one of the decision-makers behind the acquisition of the system was professionally linked to the project, and when the purchase of new replacement equipment was brought to the table, it led to major tensions and rejections of the system. This lack of support, combined with bad press and negative perceptions of the system, decreased its support to a point when the Mayor also condemned the project and killed the program, even if this meant that the City would lose all the money it had invested in the project.

In San Diego, the City has been involved in the planning and implementation process of DECOBIKE, but its role and attitude was criticized by the population. Residents complained that the City did not really care about the project nor the potential benefits to the local population by letting DECOBIKE run and implement the system the way they wanted and not consider the population's opinions. The lack of City support for the implementation of a less lucrative-focused and more citizen-focused system has allowed

DECOBIKE to act freely and open stations in conflictual places that brought frustration and rejection of the systems by some residents.

Another political topic that greatly influenced the failure of Pronto! is the mandatory-helmet law enforced in Seattle. It has been proven that mandatory-helmet laws reduce cycling and bike-sharing levels. It reduces the spontaneity associated with bike-sharing, among other reasons. The smaller number of cyclists on the streets makes the streets more dangerous for those who continue cycling. The law also led the system to sell helmets, which was complicated and added to the costs of a system which was already insolvent. When creating new regulations for dockless bike-sharing start-ups, the City of Seattle decided to not impose the distribution of helmets by the companies and let police officers decide whether or not they would enforce the mandatory-helmet law. In other words, the City tried to help the new systems by diminishing the inconvenience linked to the mandatory-helmet law, in the hope that this flexibility would lead to higher ridership numbers. When looking at other systems located in places where a mandatory-helmet law is enforced, it is clear that the law is having negative effects on ridership and that the cycling schemes would benefit from a more flexible or simply abolished law.

According to the four cases studied here, a city's cycling culture does not seem to matter that much when it comes to the success or failure of a bike-sharing system. For example, Seattle has a good cycling culture, and a lot of its residents are outdoorsy people who enjoy physical activity. Yet, this did not prevent the system from having low ridership and ultimately failing. It certainly does not hurt to already have a good cycling community when a bike-sharing system is being implemented (having more cyclists on the streets increase their safety and visibility), but it does not constitute a prime factor in the death or life of a cycling scheme, especially considering that many users are drawn from public transit and did not necessarily ride before.

6.6. Environmental factors

Climate does not seem to play a major role in the propensity of people to use a bike-sharing system, and therefore is not a key factor in predicting success or failure. Some very popular systems are located in areas with very bad climate, like Montreal, or even, to some extent, New York City. Of course, ridership numbers diminish during cold winters, but this does not impact severely the programs affected, since the number of users increases again when temperatures are pleasant. BIXI closes during five months to avoid winters, while Citi Bike users, like bike-sharing riders in Toronto, still use the system in the winter, although to a lesser degree. In Seattle, the rainy climate was often mentioned as possibly being a deterrent for cycling, but in the end, it appears that this is

probably not one of the main reasons why people did not use Pronto!, other factors seeming more important.

In the case of Citi Bike, climate impacted the system's early struggles, but that was under exceptional circumstances. Indeed, Hurricane Sandy destroyed part of the system's equipment a few months before its launch, causing delays and money losses. Fortunately, the system recovered from the event, but it did add another burden to the challenging implementation of the system.

Geography could have an impact on a system to the extent that bike-sharing bikes, which are heavy and often do not have a lot of gears, are hard to manoeuvre on hilly terrains. This was mentioned in the case of hilly Seattle: the 3-gear bikes were not adapted to the conditions in the Emerald City. Electric bikes were considered by the City to make it easier for people to climb hills, but the idea died with the project when it was cancelled. Some of the new dockless bikes in Seattle have seven gears, which should help to climb the hills. However, it is still too early to say if this change will make people take a bicycle to go up-hill (65% of Pronto!'s rides were going downhill). As for electric bikes, they represent a good solution to make cycling easier in hilly communities, however their prices can make them less desirable from a financial point of view. More studies would have to be done to measure the benefits and impact of electric bikes on ridership numbers.

CHAPTER 7:
RECOMMENDATIONS

Based on the findings from the case studies, we can offer recommendations to cities wishing to implement a bike-sharing system or improve the outcomes of an already existing scheme. These recommendations refer to financial and business models, the system and its operations, relationships with stakeholders, and related political factors.

Financial and business models

- Adopt an approach focused on the public interest and consider a bike-sharing system as a public transportation mode. Its priority should be the public interest, not its profitability. Having a profitable system is excellent, but it should not be the primary goal as it might work against the public interest.
- Get the city's political/administrative support and involvement in the project. They can help get communities involved, while also participating in the funding, implementation, functioning, and future projects of the system.
- Hire a bike-sharing company with expertise in the field, a strong reputation, and healthy finances to run the program. Since having a city run the system can be risky, it is recommended that the city work with expert partners, while remaining involved in the project. A city should not be in charge of the system, as it does not have the expertise in the field, which can lead to mistakes and problems.
- Refrain from establishing a completely privately-funded program, unless it receives lucrative sponsorships that allow for low user fees. Funding through an advertising company may be considered, although further studies should be conducted in order to fully understand the advantages and drawbacks of this business model. Privately-funded systems tend to have either high user fees or business approaches which do not favour the public interest.
- Set clear and attainable program goals, make realistic ridership forecasts, and plan accordingly. Create and enforce a framework to maintain a certain degree of control or influence over some aspects of the project.
- Evaluate who the target audiences are, and where their locations and activities are, in order to better adapt the system to their needs and therefore make it more attractive.
- Offer many rates and payment options to users, in order to attract new customers (for instance, groups or users who want to share a membership).
- Do not adopt an hourly rental rate pricing structure so as to not compete with local bike rental shops. The aim of a bike-sharing system is to offer another public transportation option for commuters and for utilitarian trips. It is not aimed at long, recreational rides.

The system and the company's operations

- Launch a system with a sufficiently-large size in terms of bikes, stations and area. The system will be more attractive since people will be able to go to more places, and this should attract more users and help pay back the investment. Starting with a small system might not attract enough users to fund a further expansion. To work successfully, experts suggest a system to have around 20 to 28 stations per square mile.
- Create a cohesive, dense network of stations and locate them at transportation hubs and popular destinations like employment or recreational areas. Install stations in residential areas, since it is often the point of origin or destination of a commuter ride.
- Expand the system as the demand grows, otherwise the system might reach its saturation capacity, which will generate efficiency problems and can impact the users' perception of the system.
- Locate stations in low-income areas since people would greatly benefit from additional transportation options. Even if these are not the most lucrative stations in the system, the system's mandate includes to the need to reach all citizens, and especially those in need of more transportation options.
- Evaluate the geographical and climatic conditions and consider options to counterbalance negative factors. Refer to the target audience. For instance, electric bikes can be good for hilly cities, but bikes with more gears might be sufficient to make people ride uphill. That said, according to studies, electric bikes are often more popular than non-electric ones, therefore it might attract more people (Gutman, 2016). If winter is harsh, evaluate if it is more cost-effective to let the system run in the cold and snow and simply maintain it more often, or if it would be more appropriate to stop the program during the winter, like in Montreal, and store all equipment inside to protect it from the elements.
- Use new technologies that can improve systems. For instance, new inter-modality technology allows customers to use the same card for public transit and bike-sharing systems. Dockless systems, or hybrid systems, like Portland's BIKETOWN, should also be considered since they reduce costs.
- For dockless and hybrid systems, regulate bike parking options to prevent bike nuisance in public and private spaces.
- Monitor trips and use data to improve the system's efficiency (e.g. rebalancing of the system).

- Ensure the operator's management practices and structural rules are efficient, and that its operations like bike redistribution and maintenance/repairing are quick and efficient.

Relationships with stakeholders

- Include citizens in the process from the start and incorporate their opinions in decision-making processes. They are the beneficiaries of the program, therefore their opinions should be taken into account.
- Be transparent to the population, the operator, other agencies, and governments. Share data. The trust of the public and stakeholders is at stake and could threaten the system if it is lost.
- Offer discounts for low-income people as well as other groups like seniors in order to increase the system's accessibility.
- Promote the system amongst different target audiences and customize the approach based on the audience.
- Connect and create partnerships with other transportation-related agencies and companies. This might encourage a better integration of the bike-sharing scheme within the public transportation network, while also encouraging inter-modality and allowing possibilities for discounts for users.

Related political factors

- Invest in the city's cycling infrastructure. If a city wants to implement a bike-share, it should invest in its cycling network at the same time, or do it before implementing a cycling scheme. This will make cycling safer and will attract more people, especially those who are hesitating about cycling in the city.
- Do not implement a mandatory-helmet law, and if one already exists, repeal it or do not enforce it.

CHAPTER 8:
CONCLUSION AND LIMITATIONS

In this study, we have looked at four case studies of bike-sharing systems in North America: Montreal's BIXI, New York City's Citi Bike, DECOBIKE San Diego and Seattle's Pronto! The first two are considered popular and successful, while the two others are seen as unsuccessful systems, Pronto! even closing in March 2017. That said, they have all faced major issues or problems throughout the years, and they have solved them in different ways. By looking through their financial and ridership histories, as well as their business models, political contexts and several other elements, we were able to determine a series of major factors that contributed to the success or struggle of each system.

These factors are varied, from mandatory helmet laws to funding sources, public outreach and geographical factors. These factors allowed us to formulate recommendations for cities wishing to implement or improve a bike-sharing scheme. Major recommendations include the involvement of municipalities throughout the process, in order to make sure the interest of the public is prioritized. Having their political and administrative support can facilitate the mandate of a cycling scheme as a service to the population. The hiring of an operator company with an expertise in bike-sharing is also recommended to ensure that the system is run and maintained adequately. Sponsorships are a great way of funding a scheme, but in most cases, systems should also be subsidized through public funds in order to make sure that they are accessible to all citizens. User fees should also remain as low as possible for the public interest. Cities and operator companies should consider bike-sharing system as another mode of public transportation, and not as a lucrative business. They must work to create partnerships with other transportation agencies and connect the system to other networks in order to increase inter-modality and transport options for citizens.

Operators must also aim at creating dense and large systems from the start, in order to join the highest number of citizens. Systems should be expanded as soon as possible, and residential and low-income areas should also be included in the network in order to reach as many residents as possible. The system should be flexible in order to respond to the demand, and geographical and meteorological conditions should be taken into account to select an operational structure and equipment that would fit best in local conditions. Target audiences should also be defined to make sure that the chosen approaches, such as marketing or station location, respond to their needs and wants. Technology should also be used to make the system more efficient, flexible, and adapted to the demand.

Including different stakeholders throughout the process, like community and advocacy groups, political officials or municipal and transportation agencies, is a good way to get as much support as possible and to make sure that the system is adapted to

local needs and context. The public should have a chance to share their thoughts on the project since they are its beneficiaries. Transparency during the entire process is also crucial for keeping the different stakeholders' trust towards the operator and the system. Moreover, the company and scheme's activities should be monitored, and data should be accessible to the public to demonstrate its good faith. These data should also be used to adjust the operations and system in order for them to be more efficient and better respond to the users' needs.

Rates should favour citizens and be varied enough to appeal to different types of users. Systems should not compete with local bike rental shops and should instead focus on providing options for commuters and for utilitarian trips. They should include discounts for vulnerable or marginalized populations to attract them towards cycling. Cities should also invest in cycling infrastructure to make biking a safer and more appealing activity, which would impact a system's ridership. They should also refrain from adopting a mandatory helmet law, since it deters people from cycling and using the system.

Finally, to succeed, a cycling scheme needs to: attract riders by meeting their needs; maintain good relationships with its stakeholders to receive and preserve their support; have appropriate operational, financial, and structural models; create a large and dense network of stations; and secure steady funding streams.

Elements and factors present throughout the literature on bike-sharing are supported by this study's conclusions. For instance, many studies note the negative impacts of mandatory helmet laws on cycling and bike-sharing schemes in Australia, and this study reinforces those findings by reaching similar conclusions through a different example. The study also contributes to the literature by tackling subjects which have received less attention, such as the impacts of different types of bike-sharing business models and the role played by communities in the development and implementation of bike-sharing systems. Moreover, while BIXI and Citi Bike systems appear frequently throughout the literature on bike-sharing, the other two cases have not attracted a lot of attention. One reason for this could be their more recent implementation (end of 2014 for Pronto! and beginning of 2015 for DECOBIKE San Diego). BIXI has attracted attention from researchers because of its status as a pioneer system in North America and in the field of bike-sharing innovation and technology. As for Citi Bike, its large presence in the literature could be partly attributed to its location in one of the largest and most famous cities in the world, as well as its high visibility and use, which made it a good choice for studies wishing to collect data on users, for instance. By assessing systems which are rarely mentioned in academic literature, the present study's findings and conclusions contribute to increasing the range of academic material accessible on the topic of bike-

sharing systems and offer new information for people to better understand and compare schemes in different contexts.

This study only looked carefully at four different bike-sharing systems, which does not begin to represent the large extent of types of cycling schemes in the world. Therefore, this study's recommendations have to be considered in their context. Other systems with different conditions and models than those recommended here may be successful in different contexts. It is also important to consider the North American context in which the study was done. These examples are taken from cities which are different from each other, but still remain on the same continent. They have seen bike-sharing emerge around the same time, with similar technologies being implemented throughout the two countries. Partnerships and influences between the different scheme operators and companies have happened mostly within the United States and Canada. Therefore, there is a sort of "bubble" surrounding bike-sharing in these two countries, and the recommendations provided here should be considered with a grain of salt when looking at other cultural contexts such as Europe. Some points might remain relevant, but there might be as well different contexts where North American models would not perform well. A deep study of successful and unsuccessful systems in other cultural, political and social contexts, such as Western Europe or China, would allow to provide a better picture of the bike-sharing phenomenon, which would be useful to have a more comprehensive view of factors that are generally beneficial for systems.

The case study method allowed to identify factors which have an impact on bike-sharing systems' outcomes, but it did not assess the exact strength of a factor in comparison to others. Therefore, we cannot order factors in terms of their impact on a system, but can simply enumerate them and mention those which appear more often and prominently throughout the cases, without putting them in specific order. For instance, in Seattle, the mandatory helmet law and the small size of the system were both seen as contributing factors, but it is hard to tell which one had a stronger impact on the outcomes of Pronto! than the other. In the case of San Diego, the for-profit structure of the company was a major obstacle to the success of the system since it influenced the locations of the stations. However, if other decisions would have been taken, maybe the system could have been more successful while still having a similar business model. There are successful systems which are owned by for-profit companies, such as advertising company JCDecaux, and this proves that a factor's impact can vary greatly from one case to another, as well as based on the other factors surrounding it. Thus, this study's recommendations are there to provide guidance, and cities should always consider their proper context and also look for additional references from cities with similar political,

demographical and environmental contexts before making decisions on a current or future scheme.

That being said, there is one recommendation that should apply to every public bike-sharing system: it should always work with the interest of the public in mind, as local residents are the ones who will decide of the fate and success of a system.

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