How Digital Platforms Materialize Sustainable Collaborative Consumption: A Brazilian and Canadian Bike-Sharing Case Study

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Abstract

Pollution, resource depletion, and to a lesser extent, global warming called into question mass consumption. Political (e.g., politicians), media (e.g., TV broadcasters, tech giants), and supranational entities (e.g., United Nations) nudged societies into alternative consumption forms that have been deemed more sustainable, such as collaborative consumption (CC). This paper aims at proposing a theoretical-empirical model that explains the materiality of sustainable collaborative practices through a bike-sharing system. The study further analyzes how connections, mediations, and inductions occur between individuals, platforms, and providers in collaborative consumption. This study examines the bike-sharing system of Porto Alegre in Southern Brazil and Vancouver's bike-sharing in Canada. We tracked these actants using the Actor-Network Theory through 30 interviews with consumers and managers. The findings suggest a dynamic ecosystem of mechanisms that mediate interactions and enact "sustainable collaborative consumption (SCC)" through digital solutions and physical equipment. The findings illustrate actors' partnerships and hybrid practical relations, establishing connections, inductions, and mediations. The results reveal that SCC is positively influenced by three avenues: 1 – sustainable individual actions; 2 – digital platforms; and 3 – sustainable physical equipment. Moreover, the research contributes to a new view of understanding the collaborative economy in a sociotechnical view.

Keywords: Collaborative consumption; digital platforms; materiality; bike-sharing; sustainable consumption.

Introduction

Clean and smart cities generate less pollution, ensure higher security levels, and provide better mobility for their citizens (Shaheen, Guzman, and Zhang 2012; Cohen and Kietzmann 2014; Cerutti et al. 2019). In this sense, some studies focused on sustainable cities (B€orjesson and Eliasson 2012; Cohen, Almirall, and Chesbrough, 2016). In this way, sustainability literature has explored public bicycle platforms' benefits from several perspectives, including users' viewpoints (e.g., Cerutti et al. 2019). For example, these studies point out benefits for urban mobility, citizens' health, city economics, and environmental preservation, as the bike-sharing system might emit fewer polluting gases into the air and nature (Cohen, Almirall, and Chesbrough 2016; Levrini and Nique 2019; Sun and Ertz 2021a). However, it is necessary to understand how urban administrators, traffic coordinators, consumers, and economy providers

formulate urban public policies to develop sustainable consumption through bike-sharing platforms (Buehler and Pucher 2012; Henley 2013; Wang and Moriaty 2018; Cerutti et al. 2019).

Fundamentally, bike-sharing platforms create value by reducing pollutions and traffic jams in big cities fostering sustainable collaborative consumption (Cohen and Kietzmann 2014). Those critical benefits of bike-sharing platforms depend on how many consumers, cities, and providers share different roles, times, and participation (Cerutti et al., 2019; Sun and Ertz 2021a). For this, the sharing economy (SE) presents as a part of society's movement associated with the diffusion of new technologies, devices, and collaborative consumption (Heinrichs 2013; Ertz and Boily 2019). The popularization of the Internet led to the spring of several Peer-to-Peer (P2P) platforms enabling, as intermediaries, to connect millions of consumers and providers worldwide (Heinrichs 2013; Hossain 2020). This activity, which digital platforms are a part of related to habits and traditions of consumption involving new values, practices through social-technological developments (Belk 2014a; Eckhardt et al. 2019). Also, this phenomenon provides a new path to sustainability through access to reused resources through shared and collaborative consumption (Bardhi and Eckhardt 2012; Heinrichs 2013; Ertz and Leblanc-Proulx 2018; Alzamora-Ruiz et al. 2020)

In this context, the information and communication technology (ICT) infrastructure provides sustainable economic development and high quality of life in big cities (Cerutti et al., 2019; Lee, Lee, and Yoo 2020; Sun and Ertz 2021a, 2021b). Thus, the growth of sharing economy services has dramatically changed consumers' behaviors, exemplified by ridesharing platforms Uber and Lyft and bike-sharing platforms (Levrini and Nique 2019; Cheah et al. 2020). Moreover, public-policy managers face significant challenges in monitoring this new consumption behavior to increase cycling in big cities (Cohen and Kietzmann 2014; Cerutti et al. 2019). Common examples of such challenges are adapting old cities' infrastructure to this new behavior, such as parking installations, lines marking the space on streets and lights for speed control in traffic (Wang and Moriaty 2018), and safety considerations (Börjesson and Eliasson 2012; Parkin 2016). In this way, bike-sharing suggest these multiple benefits, whether in the health of the people by physical exercises or as an alternative for reducing pollution and traffic in the cities (Brand et al. 2020; Cerutti et al. 2019; Cheah et al. 2020; Lee, Lee, and Yoo 2020).

Empirical evidence has demonstrated the pro-environmental benefits of bike-sharing, indicating that bike-sharing contributes to reducing the number of cars and buses on the road

(Cohen and Kietzmann 2014; Lee, Lee, and Yoo 2020), changes positively individuals' behavior in metropolitan areas (Fishman 2016), and that its most advanced form (i.e., free-floating bike-sharing) fosters resource conservation (Sun and Ertz 2021a). Therefore, new consumption and mobility behaviors are emerging in big cities and may spur sustainability through collaborative consumption, especially among the young (Cerutti et al., 2019; Echegaray and Hansstein 2020). On the other hand, technological advances further offer novel opportunities in changing the consumption behavior since it allows the upcoming of new modalities such as public sharing or payment of annual subscriptions with access eased by digital platforms (DP) (Bardhi and Eckhardt 2012; Ertz and Boily 2019; Basili and Rossi 2020). However, studies have not yet provided adequate empirical evidence of how social-technological experiences through bike-sharing promote sustainable collaborative consumption.

To better understand such changes in the individual's behaviors, it is necessary to understand the guiding factors of social and technical actions, which generate the conditions and inductions in the sharing economy (Da Silveira and Hoppen 2019). Another alternative explains the advantages and disadvantages of using digital sharing platforms in people's daily lives in big cities (Sun and Ertz 2021a, 2021b). More specifically, Möhlmann (2015) justifies the need to understand the inter-relations and endogenous and hybrid inter-dependencies of consumption mediated by such digital platforms. De Reuver, Sørensen, and Basole (2018) and Ertz and Boily (2019) explain a social-technical booking that intermediates the exchanges, intensifying sharing interactions, as in the bike-sharing case, stimulating a sustainable healthy mean of transportation and ecologically correct consumption. We understand that as a marketer-managed platform (Lamberton and Rose 2012) (e.g., Bixi, Mobike, Ofo), bike-sharing constitutes more of a “pseudo collaboration” system that squarely fits with conventional consumption (Ertz, 2020; Sun and Ertz, 2021c).

In the current study, pro-environmental behavior is conceptualized as having multiple dimensions, consisting of social, technological, economic, and environmental domains (Lee, Lee, and Yoo 2020). This behavior receives multiple experiences influences and primarily through CC practices (Botsman and Rogers 2010). Collaborative consumption (CC) is considered a contemporary phenomenon that takes on multiple and contradictory forms: 1) an economic opportunity (Acquier, Daudigeos, and Pinkse 2017; Sundararajan 2017); 2) a more sustainable form of consumption (Lee, Lee, and Yoo 2020); 3) a path to a solidary and sustainable economy (Hira and Reilly 2017; Sun and Ertz 2021a, 2021b); 4) the creation of

unregulated markets (Martin 2016); 5) a reinforcement of a neoliberal paradigm of economic organization (Martin, Upham, and Klapper 2017; Kinder, Jarrahi, and Sutherland 2019); and 6) a field full of dynamics and innovations (Laurell and Sandström 2017; Ertz and Boily 2019, Hossain 2020).

However, these definitions share sociotechnical and economic structures established by consumers - platforms - providers (Martin 2016; Eckhardt et al. 2019). Thus, the question about collaborative consumption initiatives emerges, in which the connections, interactions, and exchanges that occur between product/service providers and consumers depend on the performance of intermediary actors (platforms) that materialize the transition of this consumption practice to sustainability (Hira and Reilly 2017; Lee, Lee, and Yoo 2020). Therefore, several discussions are opened on how interactions, relations, and mediations between consumers, service providers, and entrepreneurs with digital platforms occur (Da Silveira and Hoppen 2019). More specifically, we attempt to address two research questions:

RQ1 - How do digital platforms, with their resources, mechanisms, and algorithms, directly impact individuals' behavior?

RQ2 – How do digital platforms mediate connections and generate inductions to materialize sustainable collaborative consumption?

Therefore, this study aims at proposing a theoretical-empiric model that explains the materiality of sustainable collaborative practices through a bike-sharing system. Such a model describes how collaborative consumption behavior happens through digital platforms by analyzing how connections, mediation, and inductions among individuals, platforms, and providers occur in the collaborative economy. This study is different from some recent reviews on the collaborative economy in two ways. Prior studies have examined sharing and collaborative economy from a sociotechnical perspective (Kinder, Jarrahi, and Sutherland 2019; Da Silveira 2020). Thus, we can provide a holistic view of the collaborative economy to enrich the literature. Also, our study focused on technology platforms' role (Sutherland and Jarrahi 2018). As collaborative and sustainable consumption advances (Leblanc-Proulx and Ertz 2018; Lee, Lee, and Yoo 2020; Sun and Ertz 2021a, 2021b), new views may emerge and support different studies that focus more on the theoretical aspects and empirical in this context.

Thus, Actor-Network Theory (ANT) was used in this study since it assumes that humans and nonhumans are symmetric (Latour 1997). On the other hand, the ANT is empirically realistic and allows an interpretative comprehension of how an event or phenomenon develops through practices and relations from different actors (Latour 2013; Bajde 2014). Besides, ANT

clarifies how these relations may be established, exploring the role and the agency of digital platforms to promote sustainable sharing among the actors in the consumption activities (Kinder, Jarrahi, and Sutherland 2019; Da Silveira 2020; Lee, Lee, and Yoo 2020). This research was performed with 28 consumers and two managers from the bike-sharing system from Porto Alegre, in South Brazil, and Vancouver, in Northwest Canada.

The findings of the research contribute both theoretically and practically. On a theoretical issue, this study promotes a better understanding of sustainable collaborative consumption (SCC). In other words, how this SCC is materialized through digital platforms and physical pieces of equipment like solar energy and bike stations. These results illustrate hybrid practical relations between consumers, services providers, digital platforms, and physical parts of equipment in bike-sharing stations and sites. At a practical level, the findings lay the foundations to understand how to happen the actions, motivations, and consumer behavior that adopt collaborative consumption activities, promoting this emerging issue.

The rest of the document is structured as follows. In part 2, the theoretical background necessary for tackling the established research question is presented. In this section, an extensive literature review oriented toward identifying factors that would predict the materiality of sustainable collaborative consumption was carried out. In section 3, the methodology applied is explained. Then, in section 4, the two study cases are described, and in section 5, findings are discussed. Lastly, section 6 presented conclusions, implications, limitations, and future research avenues.

Theoretical background

Sustainability in the cities: the role of bicycles

Cycling, especially as a means of transportation in the city, reappeared in the '90s (Brand et al., 2020). However, this bike behavior had been used for decades in Asian countries with high population density for all usage types (Cheah et al. 2020; Lee, Lee, and Yoo 2020; Sun and Ertz 2021a). According to Ogilvie et al. (2004), in a population census performed in the year 2000, the Chinese city of Beijing alone had 4 million bicycles in use (approximately 500 million in China) and around 80 million bikes in Japan, responsible for 17% of the daily commute to work. For Henley (2013), over 535 bicycle-sharing systems, public and private, in over 49 countries, using over 2 million bicycles worldwide. Bike paths and the increasingly more prominent promotion to their use in cities and the essential point in all planning of cities from the future,

provoking a change in behavior and individuals' lives, in the sense of a better quality of life (Cheah et al. 2020; Sun and Ertz 2021).

Public transportation services have been adapted to the uncoordinated growth of cities and traffic increase, mainly of cars. Therefore, some modalities have been created, such as exclusive bus lanes, inter-modal services combined with subways, other services, and bicycles (Cerutti et al., 2019; Echegaray and Hansstein 2020). In many cases, bikes are the fastest, most economical, cleanest, and healthiest way to circulate within the cities' downtown (Cerutti et al. 2019; Sun and Ertz 2021a). Furthermore, the interest in participating in activities in the sharing in general and CC, in particular, is linked to the need to reduce environmental impact, to seek the well-being of society, or to promote a more sustainable lifestyle, like use bike-sharing system (Alzamora-Ruiz et al. 2020; Brand et al. 2020). Bike-Sharing using in the city, available and rent in several stations and neighborhoods, already has loyal clients-users, who search beyond an economic gain and clean and promising traffic (Cohen and Kietzmann 2014; Lee, Lee, and Yoo 2020). Sharing alleviates cyclists of having to buy, maintain and protect their bicycles, proposing convenience to, for example, go to work or the university. As such, sharing solves a problem from the first to the last mile to run when living installations require trains or buses, allowing clients to travel without transporting bicycles inside the bus or trains (Liu, Jia, and Cheng 2012; Echegaray and Hansstein 2020). Bike-sharing is extremely important that expanded the business, whether public or private, of bike renting (Cohen, Almirall, and Chesbrough 2016; Levrini and Nique 2019).

In practice, bike-sharing operative equipment is projected to fit the existing traffic systems, with little or no adjustment and low costs (Midgley 2011; Liu, Jia, and Cheng 2012). For instance, de Brito Silva et al. (2020) were able to show evidence that interest in protecting the environment influenced the intention to share bikes in PE/BR. Additionally, Cerutti et al. (2019) found that bike-sharing experience happened by convenience when offered access and mobility. These offers incentivized users to shared services greater degree, focusing on sustainability and reuse with these bicycles (Cerutti et al. 2019). Also, empiric studies showed that this change of habits and behavior of individuals who search for a practical, economical and sustainable approach (Cohen, Almirall, and Chesbrough 2016; Levrini and Nique 2019; Alzamora-Ruiz et al. 2020; Sun and Ertz 2021a). However, these studies leave a gap by not explaining how the collaborative economy can contribute to sustainable consumption behavior through collaborative digital platforms. In other words, there is a gap to explain how digital platforms materialize sustainable collaborative practices through bike-sharing systems.

Digital platforms in collaborative economy context

The collaborative economy (CE) is considered a social-economic system developed and supported by new business models and digital platforms (Belk 2014b; Eckhardt et al. 2019). Thus, understanding the CE and usage of digital platforms have gained popularity in the world economic crisis since 2008 from global concerns with the lack of natural and environmental natural resources (Da Silveira and Hoppen 2019; Brand et al. 2020). In such platforms, the organizations and the individuals have the focus on transactions, interactions, and peer to peer connections, which eliminate intermediates in the process and embraces the sharing of physical and human resources, therefore providing a different configuration of business models from the traditional economy to a circular context or of sharing (Schor 2014; Bradley et al. 2017). Also, CE is considered and represented as a form of connected consumption that allows the connection of products and services to a processional dynamic where individuals through digital platforms practice actions to fit the needs and desires more sustainably, for reuse services and products. (Bardhi and Eckhardt 2012; Breidbach and Broide. 2017; Alzamora-Ruiz et al. 2020; Hossain 2020).

Consequently, Belk (2014b) and Frenken and Schor (2019) emphasize the new and varied forms of identity expression are being generated outset of diffusing the different platforms and the applications supported by the Internet and mobility. Likewise, appear new groups of individuals and organizations focusing on community-based platforms that, even when those do not possess something effective, share, or access-consumption (Bardhi and Eckhardt 2012; Lee, Lee, and Yoo 2020). Therefore, as a concept and as a practice, the CE Such individuals have become consumers and providers within a universe more focused on the virtual side. These consumers can be exposed to identities, lifestyles, and more practical or economical and socially altruistic reasons (Hartl, Hofmann, and Kirchler 2016). Such motivations also allow sharing goods and knowledge and intangible content from groups, community, and collectivity, focusing on sustainability (Alzamora-Ruiz et al. 2020; Ertz and Leblanc-Proulx 2018; Lee, Lee, and Yoo 2020).

This process happens through tools, platforms, and applications that moderate, mold, and mediate such behavior, aiming at delivering a more significant differentiation and identification in this new experience (Breidbach and Broide 2017; Basili and Rossi 2020). Within this direction, platforms may provide a process in a course that integrates actions, connections, inductions, and mediation, integrating new interactions and stimulation with social

structures or behaviors of individuals (consumers and providers), which are part of this economic and commercial structure (Scaraboto 2016; Bradley et al. 2017). In the face of this, CE and the agents that are part of such an environment generate a disturbing innovation of market transformation and the world's economies (Martin, Upham, and Klapper 2017; Ertz and Boily 2019). Such social-technological experiences are not receiving the academy's due attention when related to the comprehension of nonhuman factors, which may promote this new consumption, production, innovation, and sustainability practices (Martin 2016; De Rivera et al. 2017; Alzamora-Ruiz et al. 2020).

Platforms can centralize and decentralize actions and promote connections, interactions, and mediations with consumers and providers through their features, tools, functionalities, and algorithms (Kinder, Jarrahi, and Sutherland 2019; Sutherland and Jarrahi 2018). However, there is an opportunity to discuss the role and agency of digital platforms (DP) in materialized sustainable collaborative consumption. Thus, in this work, digital platforms are defined as virtual and physical solutions that include websites, mobile applications, wireless systems, bike stations, solar energy systems, and bike-equipment that allow quick bike-sharing and mobility services (Cerutti et al. 2019; Sun and Ertz 2021). In this context, we adopted a broad definition of DP, which includes economy and multisided platforms that offer users temporary access to tangible and intangible resources giving them access to use services (Sundararajan 2017; Ertz and Leblanc-Proulx 2018).

Furthermore, some authors will understand the platform as an ecosystem, where a set of technical actors contribute to the collaborative evaluation between consumers and producers (Basili and Rossi 2020; Ertz and Boily 2019). On the other hand, others may view the platform as a mediator, providing matching and facilitating interaction and exchange (Evans and Schmalensee 2016; Eckhardt et al. 2019). Also, DP is considered an intermediary to engage people in a collaborative consumption movement (Breidbach and Broide 2017; Laurell and Sandström 2017; Kinder, Jarrahi, and Sutherland 2019; Alzamora-Ruiz et al. 2020). Although the sharing economy uses digital platforms as a technological apparatus, it relies on social dynamics to share and collaborate to operate consumption between consumers and providers (Hamari, Sjöklint, and Ukkonen 2016; Hartl, Hofmann, and Kirchler 2016). Thus, digital platforms promote collaborative lifestyles based on sharing resources in the community, such as money, skills, and time (Botsman and Rogers 2011; Belk 2014b; Hira and Reilly 2017).

These platforms mediate both the costs of accessing providers, products, services, and consumer demand for resources, services, and goods that we access, reuse, and share (Bardhi

and Eckhardt 2012; Laurell and Sandström 2017; Basili and Rossi 2020). However, these studies tend to ignore the sociotechnical process in this triad of consumers, DP, and service providers to promote collaborative consumption in the sharing economy environment (Da Silveira 2020). Thus, there may become necessary to comprehend platforms' role in the behavior and individuals' actions while using the services and goods in collaborative and shared consumption (Ertz and Leblanc-Proulx 2018; Ertz and Boily 2019). In this way, digital platforms play an essential role in connecting people and providing rating systems and other forms of evaluation forms between consumers and providers (Acquier, Daudigeos, and Pinkse 2017; Ertz and Boily 2019). Like other structural metaphors such as 'network' or 'infrastructure, the platform's concept means different things to different audiences (Jarrahi et al. 2020; Kung and Zhong 2017). For example, these collaborative digital platform dynamics' centrality invites a more theoretically grounded understanding of digital platforms and how they operate as distinct sociotechnical structures in mediating sharing and sustainable consumption practices (Ertz and Leblanc-Proulx 2018; Kinder, Jarrahi, and Sutherland 2019; Jarrahi et al. 2020).

Therefore, this study seeks to explain the behavior of individuals in their daily lives around new information technologies, which transform social dynamics into a single network of resources, products, and services (Van der Duim 2007; Bajde 2014; Latour 1997, 2013; Kinder, Jarrahi, and Sutherland 2019). In other words, explain concretely how the collaborative economy can contribute to sustainable consumption behavior through digital platforms, mechanisms, and solutions. For this, we used the Actor-Network Theory (ANT) as a theoretical framework, which supports the proposal that aims to materialize how sustainable collaborative consumption practices occur through ICT's. ANT's theoretical basis chose because it assumes that humans and nonhumans are symmetrical (Latour 2005). In other words, ANT's practices at an event are not controlled and built by human consciousness but also by nonhuman agencies in a network (Latour 2011; Van der Duim 2007; Bajde 2014).

Actor-network theory (ANT)

According to the ANT, actors achieve their goals due to their involvement (Latour 2013; Bajde 2014). ANT's theoretical and methodological basis may help understand the CE, given the complexity of individuals' actions, which is measured by the action of the platforms, because the ANT can analyze digital contradictions (Kinder, Jarrahi, and Sutherland 2019). ANT considers the objects (or nonhuman) assume in this proposal a behavior of "intermediate," which means mediators who eventually act in times in a more meaningful way than humans

themselves (Latour 2013; Bajde 2014; Kinder, Jarrahi, and Sutherland 2019). These nonhumans can act and interfere in the general course of events mediating an action or even human behavior (De Camillis and Antonello 2016; Kinder, Jarrahi, and Sutherland 2019). Thus, this comprehension understands that such elements are in a bi-dimensional network, with social and material dimensions, which need to be analyzed in a unique and collective form (Lamine 2017; Kinder, Jarrahi, and Sutherland 2019). Therefore, ANT is a relativist theory and associates several shapes to view sociotechnical behavior (Bajde 2014; Kinder, Jarrahi, and Sutherland 2019; Da Silveira 2020). ANT establishes a direct bond between the practical and real performance in the events and facts among individuals, objects, and organizations (Van der Duim 2007; Latour 1997, 2013; Bajde 2014; Kinder, Jarrahi, and Sutherland 2019).

Consequently, it is necessary to understand digital platforms' role to materialize sustainable consumption through the bike-sharing system in sociotechnical behavior (Da Silveira and Hoppen 2019; Alzamora-Ruiz et al. 2020). This field may be studied and deepened as a group of practices, which go through entanglement hybrid movement, entangled by a group of digital actions in movement (Herrmann-Fankhaenel and Huesig 2016; Harvey, Smith, and Golightly 2017). Such actions and practices are molded according to what the process changes, and this process is propagated by the net of actors, who are part of collectivism in a single network (Scaraboto and Fischer 2016; Kinder, Jarrahi, and Sutherland 2019). In other words, those are heterogeneous relations that are relevant and are not the action properly itself (Van der Duim 2007). Therefore, this collectivism comprises human and nonhuman actors, who are represented by individuals (consumers and providers) and platforms (applications, devices, and techniques) (Kinder, Jarrahi, and Sutherland 2019; Da Silveira 2020). These actors always mold themselves and act in a flow of motion from a unique network (Latour 2013; Kinder, Jarrahi, and Sutherland 2019; Da Silveira and Hoppen 2019; Da Silveira 2020; Jarrahi et al. 2020).

For Lamine (2017, p. 626), "networks are systems of action, including human and nonhuman entities with the same level of importance given to subjects and purposes." Specifically, for ANT's there is a symmetry between the human and nonhuman agents, a fact that researchers tend to ignore, denying the role of actors, who may alter the events from analysis of the daily basis (Bajde 2014; Lamine 2017; Kinder, Jarrahi, and Sutherland 2019). Such actors connected by configurations and mediation from material elements with properties and temporary actions leave an open space for individual actions, in a unique format through the dynamic established between them, creating an engagement between both (Canniford and Bajde 2016; Kinder, Jarrahi, and Sutherland 2019). However, what can be associated,

combined, or reunite ideas, attitudes, and actions with individuals (consumers and providers), with objects (digital platforms) are actions turned to this combination or association of actors-networks or hybrid actors (Bajde 2014; Scaraboto and Fischer 2016; Kinder, Jarrahi, and Sutherland 2019). Canniford and Shankar (2016) explain this relation may be disclosed through processes and mediation generated by the characteristics, functions, data, colors, information form artifacts, or digital platforms, directly influencing human behavior related to consumption and sharing practices.

However, the ANT may also be seen as a research method (Callon 1984; Da Silveira 2020). ANT's ontology related by objects (nonhumans) is directly linked to people's behavior (humans), which means that if there is not a relation, there is no actor, and there is no network (Bajde 2014; Da Silveira and Hoppen 2019). Thus, one cannot characterize the theory only as a closed structure of analysis with a unique focus on the elements observed and followed in an empiric field (Law 2004; Kinder, Jarrahi, and Sutherland 2019). Therefore, it becomes hard to define who impacts and whether those are people (humans) or elements surrounding them (nonhumans) who generate relations and events between both and around both (Kinder, Jarrahi, and Sutherland 2019).

To enlarge the discussions for ANT, the agent described by the actor-network theory is the one that alters, transforms, creates conflicts and problems, generating differences, and producing new relations and associations in the network (Van der Duim 2007; Kinder, Jarrahi, and Sutherland 2019). In this way, it can be assumed that an interrelation between humans and nonhumans composing a collective character brings to the social side the fact that digital platforms promote a sharing economy and collaborative consumption (Kinder, Jarrahi, and Sutherland 2019; Da Silveira and Hoppen 2019). Even if mediators (nonhuman) remain quiet, they are considered and recognized in many of the analyses as intermediate in action in a network (Van der Duim 2007; Latour 2013). This network leaves of being understood as a unique thing because it is understood as a phenomenon in motion taking "things, objects, materials, techniques, and people" to another social level. (Van der Duim 2007; Law and Singleton 2013; Da Silveira 2020).

Although these actants can be human or nonhuman, their relative agency is equally treated, establishing a "generalized symmetry" during the actions, negotiations, and promotions within a given hybrid network (Kinder, Jarrahi, and Sutherland 2019). Thus, "ANT encourages "analytical impartiality" when dealing with human and nonhuman actants, allowing for an equal analysis of human and nonhuman roles within the creation or disruption of networks" (Kinder,

Jarrahi, and Sutherland 2019, p. 212). ANT scholars argue this, a set of heterogeneous elements as a dynamic collective process in motion and incorporated into reality (Kinder, Jarrahi, and Sutherland 2019; Da Silveira 2020). Thus, ANT provides many affordances, like sociotechnical design, that suggest the users and the artifacts to the same level in a heterogeneous relationship (Sutherland and Jarrahi 2018). Therefore, CC assumes a practice and connection through the platform mediation process (Kinder, Jarrahi, and Sutherland 2019; Basili and Rossi 2020) that adapts and reshapes behaviors, markets, consumption, and entrepreneurship (Eckhardt et al. 2019; Ryan and Avram 2019; Alzamora-Ruiz et al. 2020; Hossain 2020).

In this perspective, digital platforms' mechanisms mediate consumers and service providers but receive orders and actions from other stakeholders (Belk 2014b; Harvey, Smith, and Golightly 2017). In sequence happen a cooperative association by several elements for access, sharing, and collaborative consumption (Bardhi and Eckhardt 2012; Belk 2017; Perren and Kozinets 2018). For instance, digital platforms automate consumption and sustainable practices between human actors (consumers and providers), mediating and coordinating attention, emotions, and actions cooperatively and collectively (Eckhardt and Bardhi 2016; Perren and Kozinets 2018; Da Silveira 2020). On the other hand, this process depends on digital solutions, data, and algorithms that support engagement through functions, features, contents, and mechanisms by digital platforms (Kinder, Jarrahi, and Sutherland 2019; Da Silveira and Hoppen 2019; Jarrahi et al. 2020).

Specifically, this paper is concerned with presenting tensions and alliances between humans and nonhumans directly engaged with or peripheral to bike-sharing platforms. This process frequently results in the forging of new heterogeneous networks with virtual applications and physical equipment to materialize sustainable collaborative consumption.

Theoretical framework proposal

To argue that artifacts may assume a mediator role in the dynamic relations has become a fact within a society with meanings and actions generated from associations (Lamine 2017; Kinder, Jarrahi, and Sutherland 2019). According to Bradley et al. (2017), to understand the actions of engagement from individuals with the mediation of artifacts, it is necessary to understand better how the processional relations between individuals and markets occur. Thus, the digital technology platforms may create sense and exert a strong influence on the consumer decision in the sharing of products or services (Bradley et al. 2017; De Reuver, Sørensen, and Basole 2018). This process induces and connects the actors through their characteristics,

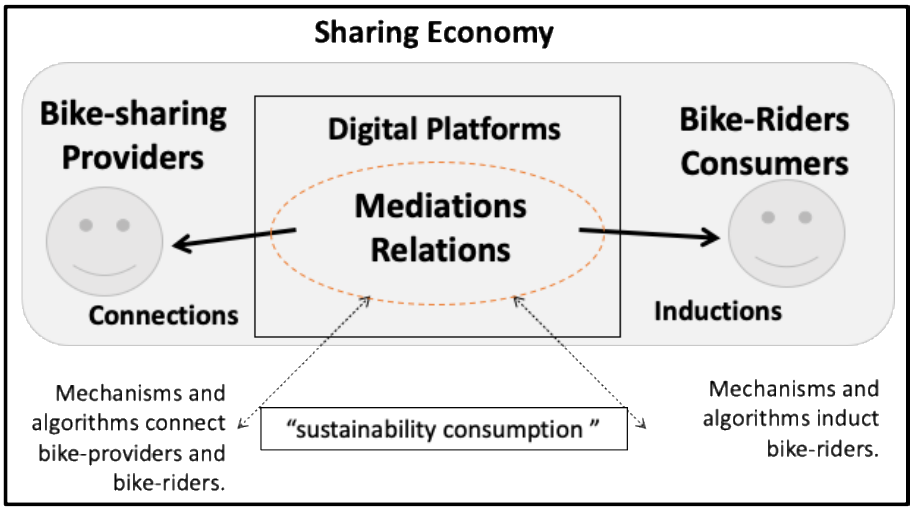
functionalities, systems, and routines (Faraj, Kwon, and Watts 2004; Harvey, Smith, and Golightly 2017). Therefore, it is plausible to consider the ANT as a theoretical and methodological support to investigate the social-technical phenomena in processes or relations developed between digital platforms, consumers, and providers (Kinder, Jarrahi, and Sutherland 2019; Da Silveira and Hoppen 2019).

These processes include contradictions, inscriptions, and maintenance of networks formed by human and nonhuman agents (Lamine 2017; Kinder, Jarrahi, and Sutherland 2019). Thus, the controversy may happen in highlighting not only the aspects and personal reasons, determined by the actions from homo-economicus, which selfishness and search for the maximization of one's gains as a basis the capitalism process (Adler 2001; Martin, Upham, and Klapper 2017). However, we consider digital platforms have functions, data, and process that were managing actions, interactions, and collaborative consumption that give counterpart, benefits of social and environmental changes for individuals attitudes in sharing (Hamari, Sjöklint, and Ukkonen 2016; Ertz and Leblanc-Proulx 2018; Alzamora-Ruiz et al. 2020).

Conceptually, ANT provides a useful language to delineate a bike-sharing system's practices through a platform and a multiplicity of external digital solutions and physical equipment (Levrini and Nique 2019; Da Silveira and Hoppen 2019). Thus, Canniford and Bajde (2016) make us think of scenery where individuals and technological artifacts participate in a structured and interconnected world by several forces that may be combined and at the same time in movement generating connections and inductions by both parts involved. Therefore, in utilizing the Actor-Network theory, we are less concerned with furthering ANT as a social science theory. Instead, we primarily aim to set up how to occur the scope of a sustainable collaborative economy in ANT lens.

Furthermore, the framework proposal (Figure 1) helps track human and nonhuman alliances that run the relationships between consumer behavior and digital mechanisms. In the second moment, capture the existence of mediation through digital platforms.

Figure 1. Proposal Framework



Source: the authors (2020).

The first macro-level framework presents the whole context of sharing and collaborative economy. This context is composed of the broad ecosystem of social, economic, market, and technological actors, which share organizational, institutional and usual structural arrangements to facilitate the interaction and exchange of resources, products, or services. In a second moment, at the micro-level, the actors partake and interact in an integrated form and a network. Within this sense, the interfaces, characteristics, and resources of design, functionalities, information systems, and communication from platforms may generate a mediation from a relational dynamic. This dynamic network communicates, connects, and induces a subtle and particular digital perspective message to individuals and providers. In a more direct aspect, sharing and collaboration interactions occur in the model from multiple processes of connections and inductions, which alter the way of seeing the world and create a sense for the usage (Da Silveira and Hoppen 2019; Levrini and Nique 2019).

At the micro-level, actors work together to create consumption practices that occur, resulting in behavior and sustainable consumption mediated by digital platforms (Ertz and Leblanc-Proulx 2018; Levrini and Nique 2019; Alzamora-Ruiz et al. 2020). Subsequently (Fig.1) highlights how the technological design, the functionalities, and the system's mechanisms generate a mediator role from a transparent and particular dynamic, which aggregates value to bike-riders and bike-providers (Levrini and Nique 2019; Sun and Ertz 2020). Our model proposes that sustainable collaborative consumption happens through a group of actors in a network that adjusts consumption behavior, focusing on the cities' pro-

environmental practices. Therefore, the perspective of connection and induction of actors is less abstract in the model's structure and presents actors' integration (consumers, providers, and platforms) within collaborative consumption (Ertz and Leblanc-Proulx 2018; Lee, Lee, and Yoo 2020).

Moreover, social individuals from this generation (millennials - Y, Z) are more likely to share and intermediate with products and services that are ecologically correct (Belk 2017; Lee, Lee, and Yoo 2020). Thus, the social dimension impacts sustainable pro-relations (Ertz and Leblanc-Proulx 2018). These pro-environmental relations are also supported by physical and digital artifacts (Da Silveira and Hoppen 2019). Those technological artifacts minimize the negative impacts that appear in traditional consumption, maximizing the positive side of the diminishing of car and bus emissions as problems associated with traffic and traffic jams in big urban centers (Cohen and Kietzmann 2014; Ertz and Leblanc-Proulx 2018; Lee, Lee, and Yoo 2020). In other words, put in evidence ridesharing and bike-sharing systems associated with sustainable consumption (Heinrichs 2013; Cohen and Kietzmann 2014; Cerutti et al. 2019; Levrini and Nique 2019; Cheah et al. 2020; Sun and Ertz 2020). Thus, this model has a theoretical contribution to illustrating how sustainable practices are materialized through behavioral changes in collaborative consumption through bike-sharing platform systems.

Materials and method

Our research compares two countries: Brazil and Canada. Thus, Bike Poa and Mobi representative examples to analyze the materiality of sustainable collaboration **practices.** In Brazil, there is an intensive predominance in the use of the car; on another side, it has the fifth largest fleet of bicycles in the world (WRI Brazil 2019). Although Brazil is a country with a large bike fleet, there is a lack of public policies to build, expand, and disseminate bike systems networks in cities. In contrast, Canada encourages its population to use bikes to commute to schools, work and leisure integrated into the public transport system. Unlike Brazil, the Canadian government has invested heavily to reduce greenhouse gas emissions since signing the Kyoto Protocol in 2002. Therefore, Canada has supported and encouraged its cities to include cycling in their infrastructure and sustainability projects (Pucher and Buehler 2006; da Silveira 2010).

Although bike-sharing has been established worldwide since the year 2000 (Sun and Ertz 2020), in Brazil, this system was only recently introduced in 2010. This new generation of bicycle sharing has quickly spread in the central Brazilian cities, with over 5 thousand bicycles

available in several stations (WRI Brazil 2019). The bike-sharing system in Porto Alegre in the South of Brazil has been highlighted because its mean use is higher than in cities such as Paris and Barcelona (6.5 trips a day per bike) (Porto Alegre City Hall 2020). Therefore, contrary to the allegations regarding this type of service, bicycles are not only shared as a complementary means of transportation or leisure but as sustainable transportation in the routine of Porto Alegre's inhabitants (Levrini and Nique 2019). In Vancouver, Canada, the bike-sharing system has been in operation since 2016, with over 180 stations and 1.800 available bikes through the 450 km of pathways from the city (Mobi 2020).

This study explored qualitatively how such materiality of sustainable collaborative consumption occurs through the proposal of a theoretical-empirical framework with ANT's support. This study examined qualitatively how such materiality of sustainable collaborative consumption occurs through the suggestion of a theoretical-empirical framework with ANT's support. Thus, the human and nonhuman actors were mapped, followed, and analyzed to illustrate how such relations occur and how they are materialized. ANT's helped establish a model to clarify how practices appeared, exploring the role of actors who partake in their actions, alliances, and negotiations in their networks (Kinder, Jarrahi, and Sutherland 2019). This way, we interviewed 30 individuals in Porto Alegre and Vancouver between September/2017 and January/2018. Within this period, participant observations were executed following the stations, information, consumers, providers, and communications in both cities. Thus, participant observations occurred in different perspectives and methodological sources (observations, field notes, informal pictures, and chats) near bike stations in Brazil and Canada with bike-sharing users.

While exploratory in nature, this qualitative study used a semi-structured script for the interviews done personally with consumers/users from the services and managers from the platforms. The participants' age group was 75% between 20 and 30 years old, 60% male and 30% female, indicating that the consumers are from the generation millennials (Y, Z), born between 1980 and 1990. For Botsman and Rogers (2010) and Lee, Lee, and Yoo (2020), the millennials generation's values are not linked and restricted to the age group, since both older and younger people share the same characteristics, everyday habits, communication, and contribution focusing on more economical, collaborative, and sustainable lifestyles. Millennials have a sustainable behavior, and collaborative consumption represents their lifestyles and consumer behavior with products, services, and more ecological business (Cheah et al. 2020; De Brito et al. 2020; Lee, Lee, and Yoo 2020).

Subsequently, to analyze sustainable practices' existence, we used ANT theory and methodologic to track alliances between consumers, providers, equipment, and digital platforms. Therefore, the analysis was inductive and thematic, but supported by the methodological bias of the ANT to trace, map, and illustrate the alliances of several existing representations between the actors in the network (Van der Duim 2007; Kinder, Jarrahi, and Sutherland 2019). This research used the codification process through NVivo qualitative codification software, which subsequently allowed the three researchers to produce themes and analyses for the collected data. Such themes were eased by the researcher's purposes and were revisited according to what researchers, collectively, understood the data. Comparing the sources was an inherent part of the interactive and collective codification process and eased the data triangulation to translate the evidence in both study cases.

Bike-sharing case studies: Bike Poa and Mobi

This comparative study between a developed country and an emergent one, both with substantial sharing economy expansion, presents two different forms to use and share bikes in big cities. Thus, these two case studies illustrate how sustainable collaborative consumption radically varies across domains and available sets of practices, thereby acknowledging this phenomenon's underlying heterogeneity. In 2012, Bike Poa was sustainable mobility with a bicycle project from the City Hall of Porto Alegre/RS, which was executed by Tembici company through a concession term (Eckert 2013; Levrini and Nique 2019). Such a system aims to amplify this mode of transportation and become a practice of healthy habits, diffusing the preserve the environment in all city (Porto Alegre City Hall 2020).

The system has over 410 bicycles and 41 stations distributed throughout the city, connected to a central through wireless, supplied by solar energy with access through a mobile digital platform, and exclusive shape and pattern. Currently, Porto Alegre city has 53 km (figure 2) of bike paths throughout several areas and neighborhoods, with information being disclosed through the app, site, and digital totems in all physical stations (Porto Alegre City Hall 2020). Within this city framework, there are pillars of a smart economy, smart mobility, a smart environment to stimulate an intelligent life, and wise use to connect public transport with the bike-sharing systems (Levrini and Nique 2019). This regional system aims to secure natural resources, human and social capital to propose quality of life and citizen participation in city governance (Levrini and Nique 2019; Porto Alegre City Hall 2020).

Bike Poa is an easy system that consumers use smartphones to request an online service rental through credit card payment for usage for 24 hours. Bikes can be collected through a mobile application or by a bike station distribute in several places near bus stations. Besides that, EPTC (Empresa Pública de Transporte e Circulação) manage the transportation system to connect and promote cycling between PortoAlegrense citizen with a proposal to reduce pollution and traffic jam (Eckert 2013; Levrini and Nique 2019). Figure (2) put in evidence bike-sharing system evolution in Porto Alegre.

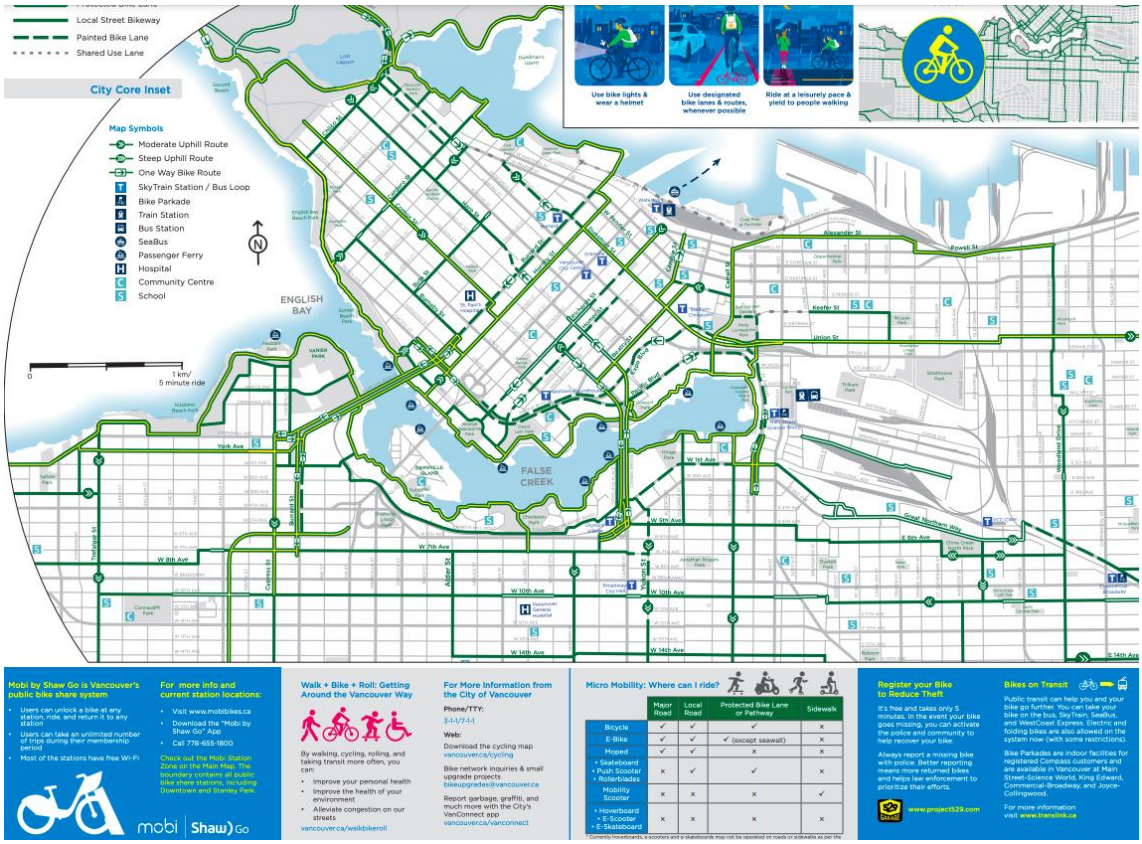
Figure 2. Porto Alegre bike lines map

Source: Porto Alegre City Transit Department

On the other side, Mobi *by Shaw Go* is a public bike-sharing program from the city of Vancouver\BC, which promotes cycling as an inherent part of daily life focused on the integration of the available mobility system and sustainability. The program currently has 184 stations spread throughout the city, with a total of over 1.500 bicycles available for local

inhabitants, visitors, and tourists (Mobi 2020). A private company operates the system, Vancouver Bike Share Inc. (subsidize of *CycleHop*), the biggest operator of intelligent systems of bike-sharing in North America (Mobi 2020). The city of Vancouver has a coverage of 450 km of bike paths (figure 3) spread through the city with connected public systems to the subway stations, taxis, and electric scooters with information available through the app, site, totems, and digital screens for access and renting through smartphones (Mobi 2020).

Figure 3. Vancouver bike lines map



Source: Mobi Vancouver Co.

Both Bike-sharing systems offer bikes, virtual maps information, physical safety equipment, and Internet wireless access through solar energy systems in their stations. Thus, after illustrating how both bike platforms are structured, we described the bike-riders' speeches how they interact with the platforms, equipment, information, and communications. The platforms with their strategies promote alliances and support for the materialization of sustainable collaborative consumption practices. Some users' behavior was followed, observed, and analyzed with their interests, attitudes, and procedures. Therefore, tables 1 and 2 present individuals/users' behavior toward bike-sharing systems in Porto Alegre (Bike Poa) and Vancouver (Mobi) cities.

Table 1. Consumer Behavior - Bike Poa platform provider

Groups	Narratives
Bike Poa users (1.Induction) (2.Connection)	*1. "Ever since I was little ride a bike, then we established this group called Pedalegre, which started with night rides, using the app of shared bikes and shared points throughout the cities, which are many and with good options in the neighborhood, where everyone can participate from a touch on the smartphone without the need of buying a bike, bringing more sustainability for the city." (Interviewee 1, 27 years old).* *1. "I like Bike Poa because it is cheap, ecological, easy to use and quite practical with the touch on the cell phone I have everything, faster than car and bus, it has several stations and the colors sign the points and the app. also, the bike paths that we have all over Porto Alegre with Internet wireless access through solar energy system". (Interviewee 10, 20 years old).* *2. "I believe that the system helps to have fewer people in traffic, less carbon gas in the atmosphere, more sustainability. Also, bike-sharing connects people to the city through a virtual app and physical equipment in all bike stations. (Interviewee 15, 25 years old).* *2. "I use the system since it is easier and connect me with a sustainable system among bus and bikes. For example, I live in Alvorada (metropolitan city of Porto Alegre), so bringing my bicycle from Alvorada to Porto Alegre is a lot of work (too far, 30 km). Thus, I need a car to carry my bike. Like the Bike Poa system, Bike-sharing is easier since location points are near bus stations and bike paths. I can access the app from touch. It connects my credit card. It has a helmet and a little basket to put my stuff and bag". Also, I can do exercises and view nature when I'm cycling around parks and routes". (Interviewee 4, 20 years old).*
Bike Poa Manager	*"We decided to bring this Canadian system to Porto Alegre, uniting technology and sustainability from the offer of bicycles in strategic points in the city, with access from the website and mainly through the mobile app, where we present a unique design and usability among the several platforms (site, app, withdraw and payment stations). The idea is to make the interface casual and transparent for users, focusing on offering an innovative, sustainable and cheap service, which may help urban mobility in big cities, diminishing the emission of carbon gas, diminishing the number of cars on the streets, and making society more economically balanced".*

Source: the authors (2020)

Table 2. Consumer Behavior - Mobi Bike platform provider

Groups	Narratives
Mobi users (1.Induction)	*1. "Translink, the government company that operates Vancouver's public transportation, encourages the use of bicycles since the year 2000 and had already created near the subway stations, spots for individual bikes that had a cost of 200 monthly dollars, then after developed a partner for shared bikes that are integrated into the system. As I used bikes before and had to maintain my bike periodically, I added the costs of storage and maintenance to choose this more economical, practical, and fast model." (Interviewee 16, 30 years old, Canadian)."* *1. "The State of BC (British Colombia) and the mayor have strongly invested in actions to improve the environment, I had in school, and I have in college much material about this subject. Bicycle is clean, does not pollute, also, takes one car off the street creating less traffic jam in our city." (Interviewee 18, 20 years old, Canadian).* *1. "British Columbia state is the state that most invests in Canada in sustainability and actions to protect the environment. We are proud of this. We are asked since school and as a citizen to have such a conscience. In addition to the Translink transport system, the mayor strongly invests in this proposal, and I believe that the bike system connected to the electric bus, subway, and electric cars are, besides that, contributing to lessen the pollution here and in the world." (Interviewee 21, 28 years old, Canadian).*
Mobi users (2.Connection)	*2. "We have bike paths integrated with bus and Skytrain, it is missing the connection to further cities, but we are on track with a focus in clean transport around Vancouver." (Interviewee 17, 25 years old, Canadian).* *2. "British Columbia, Vancouver, and North Vancouver were an example of such connected and integrated services here in Canada. We have bike paths, and integration with Bus, Skytrain (subway), and Seabus (Boat to connect the city with the cities from the North), all of these have space for own and shared bicycles, there are bike paths and rules for users that*

	need perform an online or present course that today is available on the Internet and through the app. All cyclists must also respect the car drivers' same rules regarding traffic lights, crossroads, and passages to the other lane. Still, we have a preference and no difficulties since everyone respects the cyclist. The disadvantage is our rainy and snowy weather and sometimes the lack of bicycles in the stations since the search is big in all city because this system is practical, cheap, easy and sustainable." (Interviewee 16, 30 years old, Canadian). 2. "When I arrived in Vancouver in 2017, I searched how this worked, and immediately I downloaded the app also discovered the access points together with my house and station". "The system is easy, practical, and simple that connect users to the city through digital app, virtual maps, intelligent stations, and physical communications around other public transports like metro and bus incentive bike-sharing." (Interviewee 19, 20 years old, Korean).

Source: the authors (2020)

This research identified certain factors that clear that some motivations lead to induction, connections, and engagement, related: promote the reduction in traffic, integration with the public transportation system, sustainability to diminish CO2, social attitudes to perform physical activity and well-being. In the Canadian case, there is a consolidated effort between several agents and bike platforms in the awareness with the other services in the city, focusing on sustainable practices and physical activity to the user's well-being. Meanwhile, the Brazilian case is still found in a previous state. The agents organize themselves from the change in individual behaviors impacted by the relatively new offer of bike-sharing services in the city and by a smaller network and more narrow bike paths. However, in both cases, consumers and service providers are mediated by a digital platform, which brings a new form of thinking over the environment, and unique behavior.

These findings suggest the need for a global comprehension of public managers, even in countries with shallower resources, to rethink all significant cities' critical factors, such as mobility and sustainability. We verified the materiality of the sustainable collaborative consumption practices through bicycles to diminish CO2, traffic jams, complement public transportation and perform physical activity mediated by digital solutions, physical communication, and virtual mechanisms. In both cases, respondents explain their concerns about using the bike-sharing system to reduce congestion and, consequently, carbon dioxide emission (CO2).

> *"Everybody together forms a family with a focus on sustainable for our city because not we emit carbon in our travels." (Bike Poa Interviewee 1, 27 years old). "In my opinion, this integrated system helps to reduce the cars in the city and consequently less carbon dioxide emission into the atmosphere in Vancouver city." (Mobi Interviewee 19, 20 years old, Korean).*

Meanwhile, all communications around this shared service offering in Brazil and Canada are focused on integration with public transport to encourage physical activities for the

user's well-being associated with sustainable practices. This relation among bike-sharing systems with public policies promotes all Portoalegrenses citizens' attitudes and motivations to worried about the environment. Bike Poa manager reported this behavior asymmetric among individuals and artifacts in a network.

> *"Our system has more than 180 thousand registered beyond since 2012 more than 780.000 trips have been made. After 2018 we created interactive totems and integrated them with the city's public transport system seeking a sustainable connection to public transport to amplify the mobility system to all citizens" (Bike Poa Manager).*

South Brazilian bike-sharing practice between consumers, providers, and platforms is associated with a hybrid in motion practice. This practice happens between human and nonhuman actors who interact through dynamic processes provided by the virtual systems' communication interfaces, data, tools, and functionalities through digital and physical devices. In this sense, there is an active action of technological structure from the platforms that aim at conducting the other actors (consumers and producers) to participate and execute actions that make sense for everybody (Hermann-Fankhaenel and Huesig 2016; Kinder, Jarrahi, and Sutherland 2019; Basili and Rossi 2020). For example, a platform uses communication functionalities sending messages encouraging the use of services for customers (Ertz and Boily 2019; Cerutti et al. 2019). Another example and the monthly subscriptions and connections through applications available for various devices online, at fixed stations, and on totems spread throughout Porto Alegre city (Levrini and Nique 2019).

From the provider side, we identify two connection factors that enable the venture: technology mechanisms and the ritual of the physical stations' communication process. These factors became a network pillar to promote our framework for sustainable collaborative consumption. This digital platform and physical pieces of equipment mediate sustainable incentive practices or pro-environmental behavior with their features, tools, mechanisms, and communications processes (Ertz and Leblanc-Proulx 2018; Cerutti et al. 2019; Echegaray and Hansstein 2020). In other words, the mediation process of artifacts developed connections, inductions, and engagements to materialize collaborative consumption, improving sustainable and physical practices.

In the Canadian case, there is an effort to work on induction issues from communication spread throughout the city in other available public transportation - buses, metro, and electric. This process integrates to diminish traffic, CO2 pollution, and noises in the city's central area and stimulate sustainable practices between citizens. In this case, connections are provided by

resources, interfaces, and functionalities of data and algorithms from the platform, physical totems, QR codes, and digital screens in the metro station. These digital solutions encourage individuals to participate in the action, registering their information, preferences, paths, and more used vehicles. On another side, physical equipment like bike stations, Internet wireless, city map, bike lanes, bicycle baskets, and helmets encourage access with a safe and sustainable experience. Mobi manager reports this process from Vancouver bike-sharing.

> *"Our proposal is integrating bike-sharing with the city's public transport system seeking a sustainable connection to public transport with an objective in less pollution air, and noises in the central city. Mobi offers safety equipment, digital app, maps information, and Internet wireless where all users to locate their ways and place." (Mobi city manager).*

Another factor is "Social influencer," which refers to mobility as sustainable practice and includes the variables related to the use of the bicycle in favor of sustainability (Cerutti et al. 2019; Lee, Lee, and Yoo 2020). Thus, it is possible to observe different technologies, equipment, and communication to support the bike-sharing lifestyle (Levrini and Nique 2019; Sun and Ertz 2021). For instance, the use of apps, stations, communication totems, interactive maps whose primary function is to materialize the benefits of sharing and using bikes for the environment and individuals' health. We observed that different technological resources support other behavior that expresses how Vancouver citizens perceive using the bicycle to be less polluting than regular transportation. Also, social influencers sponsored diffuse the information that each kilometer pedaled results in individual and social benefits because cycling is an "active" mode of transportation that provides substantial health benefits to individuals and, consequently, reduces costs to society (Cerutti et al. 2019; Cheah et al. 2020; Lee, Lee, and Yoo 2020).

Consequently, the use of bike-sharing apps and services has illustrated the materiality of ways to execute sustainable practices (Cohen, Almirall, and Chesbrough 2016; Sun and Ertz 2021). Vancouver interviewees referred to the app feature to show how much CO2 was being diminished by bike-sharing. This feature has established a "sustainable behavior" for those who share bikes and execute the practice through the Mobi system. Such action advises users to search for detailed information from other peers, generating a positive association between users with the provided services. Therefore, the Mobi platform uses such information, configuration, registers, and content to stimulate, mediate, and materialize service usage for all users. Aigrain (2012) highlights that such actions are idealized by robots or algorithms that test and mediate our behavior making a product or service transparent and straightforward. Thus,

we perform the transactions to do not think and only execute (Harvey, Smith, and Golightly 2017; Jarrahi et al. 2020)

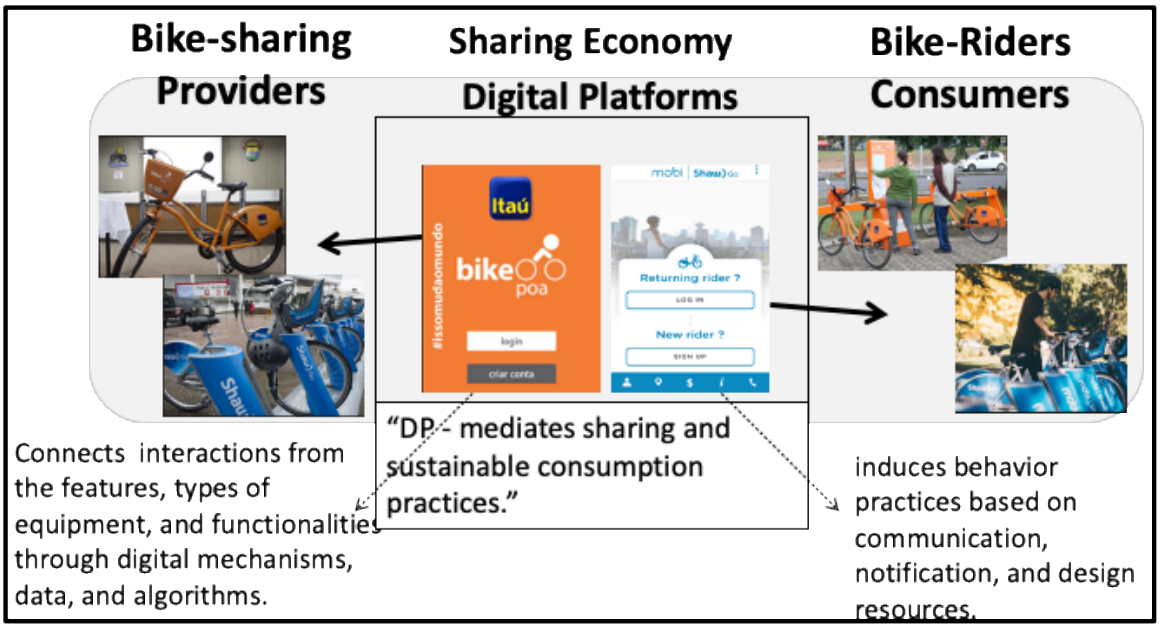
These findings suggest that the Mobi bike-sharing system is well accepted because it has a high potential to become part of users' identities. Besides, this type of service-based platform makes citizens more likely to use bicycles and realize significant sustainability impacts. From this perspective, we observed that Vancouver's public bike-sharing programs are monitored continuously and promoted in the different aspects that motivate bike-sharing system users to avoid other pollution equipment like cars. Thus, the platform manages pro-environmental collaborative consumption (Cohen, Almirall, and Chesbrough 2016; Cerutti et al. 2019; Cheah et al. 2020; Lee, Lee, and Yoo 2020; Sun and Ertz 2021).

Discussion

Bike-Sharing platforms (Bike Poa and Mobi) generate value (Zhang et al. 2018) and promote pro-environmental actions mediating the behavior of consumers and providers in cities to connect with the public transport system (Lee, Lee, and Yoo 2020). This mediation happens through useful and functional, creating multiple and associative consequences through digital and physical objects. However, this association or action is hybrid and directly depends on the link between people's behavior, which means an actor depends on the other for the action to occur and to be executed within the social and technological (Belk 2014b; Ertz and Boily 2019; Kinder, Jarrahi, and Sutherland 2019; Alzamora-Ruiz et al. 2020; Da Silveira 2020).

Figure (4) illustrates a comparative model of the cases that present a technological structure associated with designing resources, communication, functionalities, tools, and interfaces, providing a practical dynamic for sustainable consumption. This empirical evidence demonstrated mediation of bike-sharing platforms happened in generating connections and inductions that stimulated bicycles as alternative mobility in transit through healthy, sustainable, and cost-effective benefits for all citizens in big cities.

Figure 4. The illustrative model used in the research cases



Source: the authors (2020).

Overall, our findings indicate the materiality of pro-sustainability attitudes when consumers are encouraged to adopt collaborative choices by communications, organizations, policies, digital and physical technologies. Social norms oriented by digital and physical objects may also motivate citizens to adopt collaborative routines in cities (Midgley 2011; Sun and Ertz 2021a). This process has already proved useful in understanding pro-sustainability through sustainable systems like bike-sharing (Cerutti et al., 2019; Echegaray and Hansstein 2020; Lee, Lee, and Yoo 2020). Like (Ryan and Avram 2019), we may suggest adopting SCC falls far from questions of personal abilities or motivations, but to interact with digital and physical objects in different and several contexts.

However, as this research clarifies, the primary motivating points are technology-mediated, such as the network facilitator between individuals, bike-sharing systems, communications, and physical equipment. Our conceptual framework provides a useful prototype to understand pro-environmental collaborative consumption behaviors. The core tenet of evidence and theory suggests that personal norms are activated by digital solutions action and the individual motivation for them. The model establishes correlations between personal awareness, technological connections and identifies virtual, media, and physical influences on a decision on pro-environmental behaviors.

Conclusions

This study identified technology-mediated pro-environmental CC practices to influence intrinsic actions, like well-being, health, and sustainability, as well as for extrinsic actions, like financial, physical exercises, and mobility benefit. These findings also show that not all these actions contribute equally to incentivizing sustainable consumption. Personal health, an intrinsic factor, is the best connection, followed by sustainability mobility and, finally, financial benefit. These findings have generated interesting theoretical and practical contributions for this field of knowledge, presented as follows, along with the limitations and future research lines.

Theoretical and practical implications

These findings clarify that pro-environmental collaborative consumption actions are structured by several social, technical, organizational, policies, and physical pieces of equipment actors. The study results enrich the literature on the sharing economy, collaborative consumption, digital platforms, and sustainable practices to understand this phenomenon for several reasons. First, we propose a theoretical framework focusing on understanding platform influence in promoting and materializing sustainable behaviors. This research presented how SCC is materialized through digital platforms, apps, and physical pieces of equipment like solar energy, bike stations, bike lanes, interactive totems, virtual maps, and interactive screens. Second, the case studies illustrated how the social norms were oriented through digital solutions and physical objects that motivated citizens to adopt sustainable cities' routines. This process happened through a hybrid movement in-network with consumers - platforms - providers in the same action plane. Third, the study identifies intrinsic and extrinsic actions that promote pro-sustainability collaborative consumption and establish how two bike-sharing case studies cover connections, inductions, mediations, sharing, and collaborative consumption (e.g., Börjesson and Eliasson 2012; Wang and Moriaty 2018; Cerutti et al. 2019; Lee, Lee, and Yoo 2020).

The research presented sustainable collaborative practices' materiality through a network of associations, alliances, and relations negotiated between individuals, information, physical equipment, and digital technological artifacts. In theoretical-conceptual terms, the usage of ANT has allowed us to map the existence of two convergent perspectives of platforms providing a full view of how such interactions, connections, and inductions occur between bike-riders bike-providers in different moments, situations, contexts, and locations. ANT provided us a unique language to trace alliances, mediation, and materialization of sustainable practices between a series of human and nonhuman actors that surround the bike-sharing practice. The

Images, interviews, speeches, and observations analyzed have evidenced a dynamic is illustrating a multiplicity of relations, connections, inductions, and influences present among the human and nonhuman actors.

In an original form, we aimed at showing how such materiality occurs through social and technical actions that entail changes in individuals' behavior. We believed the platforms have a strong influence on the inscriptions of factors to mediate, diffuse, and promote sustainable behaviors. Digital Solutions and physical equipment provide a decision sense to mediate connections, usages, interactions, sharing, and engagements with the bike-sharing system in both cities. Therefore, bike-sharing using has changed urban trip patterns and has created a change toward sustainability in big cities (Midgley 2011; Alzamora-Ruiz et al. 2020; Lee, Lee, and Yoo 2020). This finding also offers the sharing and collaborative economy a new theoretical framework and insights into how sustainable practices' materiality occurs in a network of individual and technical actors in motion.

This study could help cities develop much more effective strategies to offer an interesting proposal to potential users on a practical level. These findings are concretely incentivizing public policies and collaborative business models to develop an environment conducive to sustainability practices through alternative mobility systems, like bikes and scooters. Second, these results showed an effective role in the platforms and other objects to transmit those benefits to consumers. In the same vein, this study suggests the investment in data, algorithms, and communication processes may auxiliary mostly demonstrating extrinsic motivators, like cost, physical activity, well-being, lifestyle, and mobility benefit. These factors will probably not boost participation in sustainable collaborative consumption but mediate this relationship.

Finally, the effective application of this framework based on the research results will help boost these types of initiatives and develop sustainable collaborative consumption, contributing to a less consumerist, pollution, and more sustainable society.

Limitations and further studies

This study showed a theoretical contribution, amplifying and inserting a new lens in the discussions input clarifications on the digital platforms' role in individuals' behavior in sustainable collaborative consumption. Specifically, previous researches tend to evaluate the environmental benefits of bike-sharing. Still, this research revealed sustainable-based

consumption through digital platforms and physical pieces of equipment that develop environmental consciences in cities.

However, we recognize the existence of other broader issues that need to be considered in this study's scope. Also, this study includes several limitations. First, two study cases analyze two different social cultures, technological stages, and sustainable concerns. Although this sustainable practice is a forerunner concerning collaborative initiatives, it is recommendable that future research bet on replicating this study in other Latin and North American economies with the goal of lending greater external validity to these findings.

Second, related to the limitations of using only two exploratory cases in the same business proposal, bike-sharing, and not comparing this system with products and services of different reason, purpose, and nature. As a suggestion for future studies, we suggested amplifying the discussion with multiple cases to comprehend and apply the model in different situations, natures, cities, services, and behavior practices. Hence, having at sight the problematic scenery and its relevance, the need to deepen the theme in future research is highlighted.

However, future studies could directly explore real motivation to sustainable collaborative consumption to determine diversified management strategies according to its target market's behavior. Third, the study focused on demonstrating how materialized sustainable collaborative consumption is through digital solutions and physical objects. However, diverse theories regarding consumer behavior indicate that the inclusion of other factors, such as attitudes, perceptions, and environmental influence, could improve the phenomenon studied. Future studies should approach these aspects independently or in a more integrated with this proposed framework.

Finally, in contrast with previous proposals, this study offers a new view, which treats human and non-human actors at the same analytical level of association. Humans and nonhumans cannot qualitatively and metaphysically be considered comparable, but they are treated for analytical and theoretical purposes. However, analytical and theoretical purposes suggested a strong influence for sustainable collaborative practice through mechanisms, tools, features, and structures of technological and physical artifacts in a single network.

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Author contributions

Conceptualization and Design – Alexandre Silveira, Gabriel Levrini, and Myriam Ertz; Methodology – Alexandre Silveira and Gabriel Levrini; Validation – Alexandre Silveira and Gabriel Levrini; Formal Analysis; Investigation – Alexandre Silveira, Gabriel Levrini, and Myriam Ertz; Writing—Original Draft Preparation – Alexandre Silveira and Gabriel Levrini; Writing—Review and Editing – Alexandre Silveira, Gabriel Levrini, and Myriam Ertz; All authors have read and agreed to the published version of the manuscript.

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