CLEAN, SILENT, SPACE-EFFICIENT AND NON-TRIVIAL URBAN FREIGHT DELIVERY: AN OVERVIEW OF CYCLE LOGISTICS IN RIO DE JANEIRO

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ABSTRACT
This paper presents information on cycle logistics (the use of bicycles and tricycles for last-mile urban freight delivery) in Rio de Janeiro. The authors first review literature on delivery of urban goods by bicycle and tricycle. They then describe the research design, and present the results of, an inventory and survey of businesses using cycle logistics in nine commercial centers of Rio de Janeiro. The authors then compare the practice of human-powered urban freight delivery in that city to current trends in bicycle and tricycle delivery in Europe and the North America. Finally, they outline a research agenda for human-powered urban freight delivery in Rio de Janeiro.

Keywords: Cycle logistics, Urban freight, Last-mile delivery, Sustainable transportation, Bicycles, Tricycles

1 INTRODUCTION

An efficient transportation system for urban freight is essential to a local economy because it ensures competitiveness of the area and generates employment (1). Human-powered bicycles and tricycles can play an important role in ensuring the sustainability of urban areas in terms of reducing emissions of pollutants and traffic casualties, and ensuring the efficient movement of people and goods and quality of life in urban areas (2–6). Using bicycles and tricycles for delivering urban freight can help reduce the negative effects of motorized freight delivery and create more sustainable cities (7–14). Last-mile delivery of urban freight is considered one of the most (or the most) expensive and polluting, and least efficient parts of the whole supply chain (15). This article focusses on last-mile deliveries via human-powered vehicles (cycles) in in Rio de Janeiro.[1]

This paper will describe data gathered by an inventory and survey of businesses conducting cycle logistics in nine commercial centers in Rio de Janeiro. After a brief literature review, the authors describe the results of the inventory and survey. They then compare the current state of cycle logistics in Rio with the literature on freight delivery by cycle in Europe and North America. Finally, the paper outlines a research agenda for cycle logistics in Rio de Janeiro.

1.1 Literature Review

This paper uses the definition of cycle logistics put forth by Schilwa et al. (2015): "the use of human powered or electrically-assisted standard bicycles, cargo bikes, and cargo tricycles for the transport of goods between A and B, primarily in urban areas" (p.52). A brief literature review conducted on cycle logistics revealed that while research on this topic has generally been scant, there has been a recently flurry of academic publications and grey literature on the topic.[2]

At present, most publications on cycle logistics come from Europe (9–11,13,14), some from North America (7,8), and very few from the rest of the world. Previous research on cycle logistics from Brazil in general, and Rio de Janeiro specifically, include a master's thesis (16) and a previous, more exploratory, iterations of the present study of cargo bikes in Rio, based on data collected in 2011 and 2012 (17). To the best of the authors' knowledge, there is no other published research on cycle logistics in Brazil, making this an important contribution to knowledge of this topic.

Literature on cycle logistics in Europe tends to emphasize the potential for "last mile" logistics by cargo bicycles or tricycles by independent parcel carriers (11–14), and some focus specifically on electric cargo bikes, which have electric-assist drivetrains, or E-CBs (9). Besides improving the economic competiveness of urban areas, the main motivation for researching and encouraging the use of cycle logistics in the European context is the promise of reducing emissions of greenhouse gases from the transport sector.

Comparisons of cycle logistics with common practice (freight delivery by motorized vehicles) have shown cycles to be competitive with motorized vehicles for shorter trips. Gruber, Kim and Lenz (9) estimate that 40% of car delivery trips in Berlin can be replaced by cargo bike, accounting for differences in travel speeds, delivery range, weight, and volume, and Wrighton & Reiter (14) estimate that 51% of all motorized trips involving the transport of goods in European cities could be replaced by bicycles or cargo bikes.

Studying North America, Conway, Fatisson, Eickemeyer, Cheng and Peters (8) and Conway et al. (7) found importance differences with cycle logistics in that region and in Europe. Whereas in the Europe, cycle logistics were generally performed by parcel carrier services (including niche and major companies in that sector) and included large corporate partners, in the US, deliveries by cycle tended to be for small, local "green" businesses that contracted third parties. In both places, the businesses engaged in cycle logistics to strengthen their sustainability credentials. Twelve companies provided cycle logistics services

[1] In this paper, the term "human-powered vehicles" refers exclusively to bicycles and tricycles.

[2] This literature review for this paper does not propose to be exhaustive – for more comprehensive reviews, please see the paper by Schilwa et al. (12) for background on Europe, and the report by Conway et al. (7) for context on cycle logistics on North America.

in 10 cities in the US and Canada, and most carried food and beverage sector goods. In both Europe and the US, deliveries included business to business (B2B) and business to customer (B2C).

Using case studies of two organizations (a bakery and an NGO) in New York City, Conway et al. find deliveries by tricycle to be generally faster than those made by trucks. They also found freight tricycles to have additional advantages of flexibility, particularly regarding the ability to bypass congested traffic and find parking that is very convenient, often adjacent to the place of delivery, and also find parking more quickly than trucks. The freight tricycles also consumed less space in the roadway (when travelling) and when parked than trucks.

Additionally, detailed studies have shown that cycle logistics can reduce emissions of airborne pollutants versus motorized delivery. Koning and Conway (10) showed that parcel delivery by cargo bikes in central Paris saved 3.5 tons of CO2 a day from 2001 to 2014, and Conway et al. found annual savings of 11-13 tons of CO_2, and PM10 savings of 2-2.5 lbs per year for a bakery in New York City.

In addition to advantages in speed, flexibility, and lower emissions found by other researchers, costs associated with purchasing cycles for freight delivery were found to be up to two-thirds lower than for motorized options, and insurance costs for a tricycle were about a quarter of those for vans (13). However, Conway et al. point out that labor costs can be greater for freight delivery by cycle logistics versus motor vehicles, because multiple cycle drivers may be needed to complete the deliveries that could be made by one motor vehicle driver. Further, insurance costs for cycle drivers are currently extremely high (in New York City).

Although the literature review for the present paper revealed a dearth of published research on cycle logistics in developing countries, this does not mean that cycles are not used for urban freight delivery outside of the wealthy regions where such research has been published. Anecdotally, the authors are aware of the use of cycle logistics throughout Latin America, including in Bogotá, Buenos Aires, Mexico City, and Montevideo, as well as in Asian and African cities. The present challenges of urbanization, including the reduction of transport sector greenhouse gas emissions, which cause global warming (18,19), local pollutants that cause respiratory illnesses (20,21), and approximately 1.25 million annual global road traffic deaths (22), warrants further research on these zero-emissions, safe vehicles, starting with places where they already make up an important part of the logistics chain.

1.2 Background

Cycle logistics appear to have a long tradition in Rio, as evidenced by an article in the newspaper *Jornal dos Esportes* (as cited in Soares Coutinho, 2013) reporting on a race of cycle delivery vehicles that was organized by the famous football club C.R. Flamengo in 1935, whereby "dozens of businesses of this capitol, 73 participants" (23) participated in a race in Copacabana. The next year's edition of the race was won by a bakery (Panificadora São João), and the same "Popular Tricycle Test"[3] was also held in 1937.

Another newspaper article (24) dated over 35 years after 1935 (1971) reports that many cargo tricycles used by businesses in the city center, and that these establishments reduce their delivery costs by up to 80% with these vehicles. The article states that these vehicles are a danger to pedestrians, and a photo shows a cargo tricycle, and has a caption "the tricycle, which does not respect traffic signal or directions, is a permanent menace in Rio." This is further evidence that these vehicles have in use for many decades in this city. Anecdotal observation suggests that the use of cycle logistics may have increased, at least in Copacabana, since the 1980s.

[3] Translation from original Portuguese "Prova Popular de Tricycles" (23) Note that, curiously, "tricycles" is written in English, as opposed to the Portuguese translation "triciclos," commonly used today.

O triciclo, sem respeitar sinais nem mãos de direção, é ameaça permanente nas ruas do Rio

FIGURE 1 Tricycle in Rio de Janeiro in 1971

2 RESEARCH DESIGN & METHODS

The data presented in this paper was gathered as part of a project carried out by the Brazilian NGO Transporte Ativo, in partnership with the Brazilian office of the international NGO the Institute for Transport and Development Policy (ITDP Brasil). The goal of this project was to discover key characteristics of cycle logistics in Rio de Janeiro. The tools applied were an inventory and survey of establishments that used cycle logistics. The inventory and survey were designed to determine the following information on human-powered vehicles for urban freight delivery commercial centers of the city:

- Number and types of establishments that used these vehicles
- Types of human-powered vehicles they used
- Who owned these vehicles
- Number of people the establishments employed to make the deliveries
- Number of daily workday deliveries
- Geographical reach of deliveries made

2.1 Description of commercial centers in the sample

The municipality of Rio de Janeiro is Brazil's second-largest municipality, with an estimated population of 6.476.631 in 2015 (25) The municipality sprawls over a vast area of 1,221 km^2 (486.5 sq mi), that measures about 70 km from East to West, and about 30 km North to South, with an extensive coastline to the South, and divided by two mountain ranges.

The researchers wished to survey a geographically diverse group of dense commercial centers of Rio de Janeiro in the city's seven sub-prefectures. As such, they consulted with a specialist at the municipal autarchy charged with implementing and maintaining projects in public spaces (RioUrbe) to select the densest square kilometer in terms of commercial activities, as evidenced by business establishments and shoppers (V. Andrade, personal communication, December 10, 2014). Considering budget and time constraints, the researchers identified nine commercial areas that contained a broad range of income and urban typologies, and were geographically evenly distributed across the city.

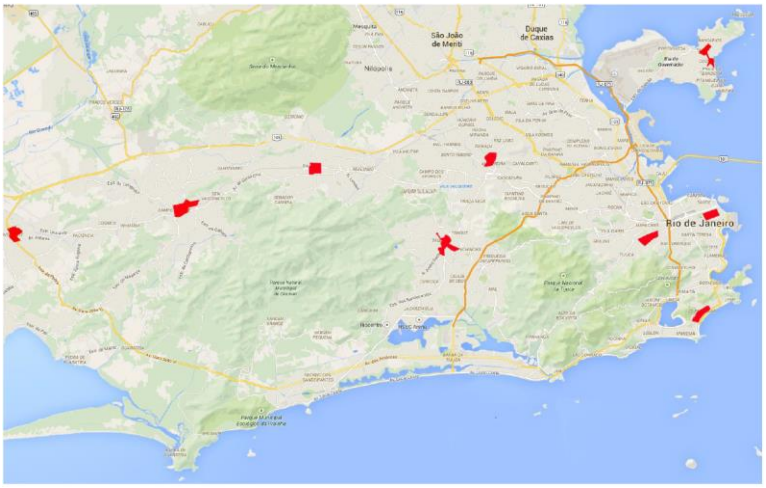

FIGURE 2 Sites of inventory and survey (Clockwise from left: Santa Cruz, Campo Grande, Bangu, Madureira, Ilha do Governador, Centro, Copacabana, Tijuca, and Taquara. Source: Google Maps and (26))

While the researchers do not claim to have attained a representative sample of neighborhoods of Rio de Janeiro, the intention of the consultation with the specialist at Rio-Urbe was to approximate such a representative sample to the degree possible given the project's constraints. The sample selected was a theoretical sample; the areas to be surveyed were chosen to help broaden the theoretical understanding of the conditions under which cycle logistics thrive. The use of such a theoretical, non-probability sample of commercial centers in Rio de Janeiro is acceptable given the budget constraints; nonrandom samples can attain a degree of representiveness without the use of a completely random methods (27).

After identifying nine commercial centers in the city's seven sub-prefectures, the researchers identified the boundaries of the areas where the inventory and survey would take place in consultation with the specialist at Rio-Urbe. The goal was to identify a square kilometer in each of the nine areas. The mean area of the survey sites was 1.03 square kilometers (standard deviation 0.05, see TABLE 1 **Sites of Inventory and Survey**).

TABLE 1 Sites of Inventory and Survey

Sub-prefecture	**Commercial center**	**Area of survey region (km^2)**
Barra e Jacarepaguá	Taquara	0.99
Centro e Centro Histórico (Center and Historical Center)	Centro	0.97
Grande Tijuca (Greater Tijuca)	Tijuca	1.01
Ilha do Governador	Bancários-Tauá-Cocotá	1.06
Zona Sul (South Zone)	Copacabana	0.98
Zona Norte (North Zone)	Madureira	1
Zona Oeste (West Zone)	Bangu	1.12
	Campo Grande	1.08
	Santa Cruz	1.09

After defining the sites for the inventory and survey, six research assistants (all collaborators of the NGO Transporte Ativo) collected the information *in situ*, by canvassing the entire area and speaking with owners, managers or other employees of commercial establishments to obtain the information. The researchers asked these personnel if the businesses used cycle logistics, and if the response was positive, applied a survey with closed-ended questions regarding the characteristics of their use of cycles for freight delivery. The research assistants conducted the inventory and administered the survey in December 2014 and January 2015.

3 RESULTS

This section presents the results of the inventory and survey of businesses of the 322 businesses that field researchers identified as engaging in cycle logistics in the nine commercial centers of Rio de Janeiro. It begins with a description of the human-powered vehicles used as well as the ownership and geographical reach of the vehicles, follows with the types of establishments that use cycle logistics, then presents data on the workers engaged in this activity, and concludes with an analysis of the differences among the nine commercial centers. An important caveat is that the survey data is self-reported, and as such may be contain one or more types of systematic error or bias (28), possibly resulting in over or underreported data versus the actual numbers.

3.1 Vehicles

Researchers found a total of 628 vehicles. Of these, 271 were regular bicycles (43% of all vehicles, see TABLE 2 **Types of Vehicles**), 216 cargo bicycles (34.5%), and 141 tricycles (23.5%). All of these vehicles are 100% human powered, and no electric cycles were found.

Regular bicycles are vehicles that are the same as any normal bicycle usually used for transportation or leisure. They have normal wheel sizes (e.g., 26 or 27 inch or 700C), and their structures are not tailored to carry freight. They may include racks, baskets or other devices to aid in carrying objects.

TABLE 2 Types of Vehicles

		
Regular bicycle[4]	**Cargo bicycle**	**Cargo tricycle**
271 (43%)	216 (34.5%)	141 (23.5%)

Cargo bicycles and tricycles are specifically built for carrying urban freight. In the first case, they usually have one or two built-in racks, usually in the front and/or on the back, on which boxes or objects to be transported can be placed. Often the front wheel is smaller (20 inch wheel size) to allow for extra carrying room, visibility and maneuverability. Cargo tricycles usually have a normal (26 inch) wheel in the back and two small wheels in front, with a wide, often enclosed platform for carrying objects in front.

Regarding ownership of the vehicles, the vast majority (90.3%) belonged to the establishments surveyed. Of the remaining vehicles, 5.4% belonged to the establishments' employees, and 4.3% belonged to a third-party logistics provider. All of the latter belonged to a mainstream (ie, not niche)

[4] All photos by Zé Lobo.

logistics firm that engages in a wide range of activities and uses vehicles other than cycles, including vans and trucks and were in the service of a major supermarket chain.

3.2 Establishments

The inventory identified a total of 322 establishments that used human powered vehicles for cycle logistics in the nine commercial centers of Rio de Janeiro. These establishments belonged to the broad categories of food and beverage (49%), manufactured goods (22%), services (15%), and health (14%) (see TABLE 3 **Establishments using cycle logistics**).

These establishments included: 51 restaurants (16%), 44 pharmacies (13.5%), 39 supermarkets (12.5%), 27 hardware & building supplies stores (8.5%), 24 pet shops (7.5%), 22 beverage distributers (5%), 21 clothing cleaners (7%), 15 juice stores (5%), 13 bakeries (4%), 13 mattress stores (4%), and 52 other types of establishments (17%) of which there were fewer than 13 total establishments counted. The last category ("other") included butchers, key smiths, lighting stores, florists, postal services, and 17 other types of businesses.

TABLE 3 Establishments using cycle logistics

Category	Percentage	Type	Number	Percentage
Food and beverage	49 %	Restaurants	51	15.8%
		Supermarkets	39	12.1%
		Beverage distributers	22	6.8%
		Juice stores	15	4.7%
		Bakeries	13	4.0%
		Butchers	9	2.8%
		Others	13	4.0%
Manufactured goods	22.5 %	Hardware & construction supplies	27	8.4%
		Lighting store	4	1.2%
		Others	9	2.8%
Services	15 %	Pet shops	24	7.5%
		Clothing cleaners	21	6.5%
		Mattress stores	13	4.0%
		Key smiths	6	1.9%
		Florists	4	1.2%
		Postal services	3	0.9%
		Others	5	1.6%
Health	13.5 %	Pharmacies	44	13.7%

3.3 Workers

Researchers recorded 658 workers that made deliveries of urban freight with bicycles or tricycles. With a 322 establishments, this gave a mean of 2.07 human-powered vehicles per business that engaged in cycle logistics (95% confidence level 1.87-2.26, standard deviation 1.75). Establishments with eight or more human-powered vehicle delivery workers included an office of the national postal service (Correios) with 15 workers, a beverage distributor with 12, a restaurant and supermarket with 10, and another restaurant and two pharmacies with eight. The recorded number of workers was slightly higher than the vehicles counted (622 vehicles), resulting in 1.05 vehicles per worker.

3.4 Deliveries and geographical reach

The survey asked how many deliveries each establishment made daily, resulting in 7,524 reported daily deliveries for the 313 establishments that gave answers to this question (nine fewer than the total 322 businesses). This gave a mean of 24.12 deliveries for each business (95% confidence level 27.03-21.2, standard deviation 1.48).

A total of nine businesses reported completing 100 or more daily deliveries included a supermarket (170 deliveries), a restaurant, pet shop and another supermarket (150), a pharmacy and a juice store (120), and a pharmacy, another restaurant, and another juice store (100). These businesses range from large, corporate supermarket chains to small neighborhood businesses.

The mean number of deliveries per worker was 12.02 (95% confidence level 13.14 – 10.91, standard deviation 10.04). The nine businesses with the highest delivery/worker ratio (40 or more deliveries per worker) included two supermarkets (75 and 70 deliveries per worker), two juice stores (50 and 40), three bakeries (two with 50, one with 40), a beverage distributor (40), and a water and ice distributor (40 deliveries per worker). These businesses with the highest delivery/worker ratios had relatively few (between one and three) delivery workers.

Most of the businesses (about 75%) made deliveries in an area of under 3 kilometers, with the remaining 25% delivering in areas up to 8 kilometers from the establishment. Six businesses delivered in an area of up to eight kilometers (five pharmacies and one pet shop).

3.5 Commercial centers

Although the areas surveyed were very similar in size (around 1 square kilometer), the number of businesses that used cycle logistics varied greatly (see TABLE 4 **Commercial Centers and Cycle Logistics**). The three centers with largest numbers of these businesses accounted for 89% of the total establishments using cycle logistics: Copacabana was home to 187 of these (58 %), Tijuca, 68 (21 %), and Centro, 32 (10%). In fact, these three areas accounted for 89% of all businesses using cycle logistics encountered in this inventory.

While Ilha do Governador, Bangu, Madureira, Taquara and Santa Cruz had relatively few businesses using cycle logistics, Campo Grande stood out because researchers did not register any such businesses.

TABLE 4 Commercial Centers and Cycle Logistics

Commercial Center	Businesses using cycle logistics	Percentage of total businesses using cycle logistics
Copacabana	187	58%
Tijuca	68	21%
Centro	32	10%
Ilha do Governador	12	4%
Bangu	9	3%
Madureira	7	2%
Taquara	5	1.5%
Santa Cruz	2	0.5%
Campo Grande	0	0%

4 DISCUSSION & CONCLUSION

The inventory and survey revealed that a non-trivial amount of deliveries are made using cycle logistics in Rio de Janeiro. The wide range of businesses that use human-powered vehicles suggest that these are practical and cost-beneficial versus motorized options, particularly in the commercial centers of

Copacabana, Tijuca and Centro, where the vast majority (89%) of the businesses that use cycle logistics found in the inventory are concentrated.

The vast range of types of businesses types and sizes found (from corporate supermarkets to small neighborhood businesses) suggest that, in contrast to Europe and North America, business' motivations for engaging cycle logistics in Rio de Janeiro do not include the desire to engage in sustainable practices, or present an image of sustainability. Rather, cycle logistics are likely to be the most economically efficient option for last-mile B2C deliveries in these places.

An important difference with Europe and North America is that while cycle logistics are often carried out by third parties in these regions, in Rio de Janeiro the vast majority of the deliveries made were completed by in-house delivery services, as evidenced by the ownership of the vehicles (only 4.3% belonged to third-party logistics providers). These types of in-house, B2C deliveries may have been more common practices in Europe in previous decades; butchers and bakers were reported to typically have made deliveries with cargo bikes from the 1920s to the 1960s (29).

While cycle logistics by parcel carrier services was common for cycle logistics in Europe, it was less common in Rio de Janeiro, where only the national postal service was found to use cycles (in North America, no parcel carrier services were reported to use cycles, Conway et al. 2014). That being said, the three post offices that used cycles in Rio used a total of 19 cargo bikes, with 20 workers making 64 daily deliveries. This suggests that there may be further potential for cycle logistics by parcel carrier services in Rio de Janeiro, perhaps if urban micro-consolidation centers (8) can be established for such services.

The domination of three commercial centers (Copacabana, Tijuca, and Centro) in the total of businesses that employ cycle logistics in the nine areas of the inventory raise the question of what circumstances allow these businesses to thrive in these areas. Copacabana and Tijuca are relatively dense, high-income areas with a more "traditional" urban typology – relatively narrow streets, and apartment buildings with street-level businesses. Centro is the business center of the city, and is also a relatively dense, active place, with a "traditional" urban typology,[5] though with fewer residential buildings than in Copacabana and Tijuca. The other areas are lower income and have are relatively less dense and urban typologies typical of peripheral neighborhoods in Latin America (eg, fewer apartment buildings). These variables (income, density and urban typology) should be investigated as possible explanations for the prevalence of cycle logistics in these neighborhoods.

The field researchers noted that in the areas canvassed with relatively few businesses (Ilha do Governador, Bangu, Madureira, Taquqara and Santa Cruz), or no businesses (Campo Grande) using cycle logistics, many establishments made deliveries via motorcycles. Many researchers have noted the increasing role of motorcycles in urban freight logistics in Latin America (30–33), along with the elevated costs that these vehicles represent to the societies of Latin American countries, particularly due to high amounts of traffic deaths and serious injuries associated with this mode. As such, future research should explore under which conditions cycle logistics on the one hand, and motorcycle logistics on the other, thrive.

Further, businesses in all nine commercial centers in the areas made deliveries with handcarts or on foot. These modes of last-mile urban freight delivery were not covered comprehensively by this inventory and survey. Future research could cover all modes of human-powered urban freight delivery, of which cycle logistics would be a subset.

Cycle logistics in Rio may also present non-trivial economies in terms of emissions of greenhouse gases and urban space. In order to determine these, a survey must be structured in a way that means for length of trip, the weight and volume of freight delivered, and deliveries per trip can be determined (this is not possible with the data from the current survey). This information would also allow for a calculation to derive the urban space that these vehicles save, both in terms of parking and road space used had the trips been made by equivalent motorized options – e.g., motorcycles (for bicycles and cargo bikes) and vans (for tricycles).

[5] Centro is actually the oldest part of the city of Rio de Janeiro.

Future surveys and/or interviews could help identify businesses' reasons for using cycle logistics, perceived problems and possible solutions to issues that could improve conditions for businesses that currently engage in, or others that may wish to engage in, cycle logistics, or for cycle delivery workers. Qualitative research and interviews with open-ended questions could be of particular value to this endeavor, as these methods potentially allow for a wider range of issues to surface than in narrower research tools, such as surveys, where responses are often pre-determined (34). Researchers have effectively used qualitative methods to illuminate dynamics behind, and discover emerging topics related to, the use of different transportation modes (31,35,36).

Another topic to be explored related to cycle logistics is the provision of services (versus delivering goods) via bicycle. While anecdotal, provision of services in Rio de Janeiro via bicycle and e-bike has been noted (37).

Given that cycle logistics are a clean, silent, and space-efficient way to complete last-mile deliveries, municipal authorities may have an interest in stimulating such deliveries. The road transportation sector is the largest source of greenhouse gas emissions (39%) originated in the city of Rio de Janeiro, and cycle logistics could help reduce these emissions (38). According to the Municipal Climate Change Law No. 5248/2011 (39), the goal of the City is to reduce carbon emissions by 20% by 2020; an increase in the use of zero-emissions vehicles (bicycles and tricycles) could help meet this goal. One way to do this could be to use cycle logistics for municipal services, as is currently practiced in numerous European municipalities in six European countries, either via in-house municipal services (e.g., street cleaning), or by contracting third-party cycle logistics firms for parcel deliveries (40).

This paper has presented the results of an inventory and survey of cycle logistics in Rio de Janeiro, and shown that the use of cycle logistics is non-trivial there, and of a considerable magnitude in three of the nine commercial centers surveyed in this sprawling, extremely populous city. It has also outlined possible areas of further research for this clean and space efficient mode of last-mile freight delivery. The authors hope that this paper can inspire researchers from around Brazil, Latin America, and other countries in the developing world to engage this topic, which can potentially help solve multiple challenges of urban places, including the need to reduce greenhouse gas emissions and noise pollution, improve public health (traffic injuries and respiratory illnesses), and make efficient use of scarce space in cities.

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REFERENCES

1. Russo F, Comi A. City Characteristics and Urban Goods Movements: A Way to Environmental Transportation System in a Sustainable City. Procedia - Soc Behav Sci. 2012;39:61–73.

2. Banister D. The sustainable mobility paradigm. Transp Policy. 2008 Mar;15(2):73–80.

3. Banister D. The trilogy of distance, speed and time. J Transp Geogr. 2011 Jul;19(4):950–9.

4. Pucher J, Buehler R. Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. Transp Rev. 2008 Jul;28(4):495–528.

5. Pucher J, Dijkstra L. Promoting safe walking and cycling to improve public health: lessons from the Netherlands and Germany. Am J Public Health. 2003;93(9):1509–1516.

6. Vasconcellos EA. Urban Transport Environment and Equity: The case for developing countries [Internet]. Routledge; 2014 [cited 2015 Nov 9]. Available from: https://books.google.com/books?hl=en&lr=&id=O2B9AwAAQBAJ&oi=fnd&pg=PP1&dq=vasconcellos+2014&ots=qMS9imEiZ-&sig=zUoq_VCQ1cM6WJ4oE-LWpZUbsRI

7. Conway A, Kamga C, Cheng J, Eickemeyer P, Chen Q, Singhal A. Freight Tricycle Operations in New York City [Internet]. 2014 [cited 2016 Jul 27]. Available from: https://trid.trb.org/view.aspx?id=1332465

8. Conway A, Fatisson P-E, Eickemeyer P, Cheng J, Peters D. Urban micro-consolidation and last mile goods delivery by freight-tricycle in Manhattan: Opportunities and challenges. In: Proceedings of the 91st Transportation Research Board Annual Meeting, Washington, DC, USA [Internet]. 2012 [cited 2016 Jul 24]. p. 22–26. Available from: http://docs.trb.org/prp/12-2682.pdf

9. Gruber J, Kihm A, Lenz B. A new vehicle for urban freight? An ex-ante evaluation of electric cargo bikes in courier services. Res Transp Bus Manag. 2014 Jul;11:53–62.

10. Koning M, Conway A. Biking for goods is good: An Assessment of CO2 savings in Paris. In: Conference proceedings, Transportation Research Board 94th Annual Meeting [Internet]. 2015 [cited 2016 Jul 24]. Available from: https://www.metrans.org/sites/default/files/MF%2014-3%202b_Biking%20for%20Goods_Final%20Report_121115.pdf

11. Maes J, Vanelslander T. The Use of Bicycle Messengers in the Logistics Chain, Concepts Further Revised. Procedia - Soc Behav Sci. 2012;39:409–23.

12. Schliwa G, Armitage R, Aziz S, Evans J, Rhoades J. Sustainable city logistics — Making cargo cycles viable for urban freight transport. Res Transp Bus Manag. 2015 Jun;15:50–7.

13. Wrighton S. CycleLogistics Final Public Report [Internet]. 2014 [cited 2016 Jul 27]. Available from: http://www.cyclelogistics.eu/docs/111/D6_9_FPR_Cyclelogistics_print_single_pages_final.pdf

14. Wrighton S, Reiter K. CycleLogistics – Moving Europe Forward! Transp Res Procedia. 2016;12:950–8.

15. Gevaers R, Van de Voorde E, Vanelslander T. Characteristics and typology of last-mile logistics from an innovation perspective in an urban context. City Distrib Urban Freight Transp Mult Perspect Edw Elgar Publ. 2011;56–71.

16. da Silva RC. CONTRIBUIÇÃO AO PLANEJAMENTO DO TRANSPORTE URBANO DE CARGA PELA ANÁLISE FÍSICA DO ESPAÇO URBANO: ESTUDO DA ÁREA DA RUA DO CATETE E LARGO DO MACHADO NO [Internet]. Universidade Federal do Rio de Janeiro; 2012 [cited 2016 Jul 27]. Available from: http://objdig.ufrj.br/60/teses/coppe_m/RobsonCoutinhoDaSilva.pdf

17. Hagen J, Lobo Z, Mendonça C. The Benefits of Cargo Bikes in Rio de Janeiro: A Case Study. 2013 [cited 2016 Jul 27]; Available from: http://academiccommons.columbia.edu/catalog/ac:197902

18. Chapman L. Transport and climate change: a review. J Transp Geogr. 2007 Sep;15(5):354–67.

19. Ribeiro SK, Kobayashi S, Beuthe M, Gasca J, Greene D, Lee DS, et al. Transportation and its infrastructure. Inst Transp Stud [Internet]. 2007 [cited 2015 Jul 17]; Available from: http://escholarship.org/uc/item/98m5t1rv.pdf

20. Brauer M, Amann M, Burnett RT, Cohen A, Dentener F, Ezzati M, et al. Exposure Assessment for Estimation of the Global Burden of Disease Attributable to Outdoor Air Pollution. Environ Sci Technol. 2012 Jan 17;46(2):652–60.

21. Brunekreef B, Holgate ST. Air pollution and health. The lancet. 2002;360(9341):1233–1242.

22. World Health Organization. WHO global status report on road safety 2013: supporting a decade of action [Internet]. World Health Organization; 2013 [cited 2015 Nov 9]. Available from: http://apps.who.int/iris/handle/10665/78256

23. Soares Coutinho R. Um Flamengo grande, um Brasil maior: o Clube de Regatas do Flamengo eo imaginário político nacionalista popular (1930-1955) [Internet]. Universidad Federal Fluminense, Nitero, RJ, Brasil; 2013 [cited 2016 Jul 29]. Available from: http://www.historia.uff.br/stricto/td/1453.pdf

24. Pedestre tem na rua ameaca do triciclo que guarda de transito nao pode coibir. Jornal do Brasil [Internet]. 1971 May 26 [cited 2016 Aug 1]; Available from: https://news.google.com/newspapers?nid=0qX8s2k1IRwC&dat=19710526&printsec=frontpage&hl=en

25. Instituto Brasileiro de Geografia e Estatística (IBGE). Estimativas de população para 1º de julho de 2015 [Internet]. 2016 Jul [cited 2016 Jul 24]. Available from: http://www.ibge.gov.br/home/estatistica/populacao/estimativa2015/estimativa_tcu.shtm

26. Transporte Ativo, Instituto de Politicas de Transporte e Desenvolvimento. Contagem de Estabelecimentos Comerciais com Entregas por Bicicleta [Internet]. Rio de Janeiro; 2015 Feb [cited 2016 Aug 1]. Available from: http://www.ta.org.br/contagens/cb/Relatorio_CargaII.pdf

27. Davidson J. NON-PROBABILITY (NON-RANDOM) SAMPLING. In: The SAGE Dictionary of Social Research Methods [Internet]. 1 Oliver's Yard, 55 City Road, London England EC1Y 1SP United Kingdom: SAGE Publications, Ltd; 2006 [cited 2016 Mar 4]. Available from: http://srmo.sagepub.com/view/the-sage-dictionary-of-social-research-methods/n130.xml

28. Trautgott MW. Self-Report Measure. In: The SAGE Encyclopedia of Social Science Research Methods [Internet]. 2455 Teller Road, Thousand Oaks California 91320 United States of America: Sage Publications, Inc.; 2004 [cited 2016 Aug 1]. Available from: http://methods.sagepub.com/reference/the-sage-encyclopedia-of-social-science-research-methods/n904.xml

29. Basterfield S. D2.1 Short History of Cargo Cycling – lessons to be learnt fro m present and future Overview of the use of bicycles for goods delivery in selected EU countries [Internet]. Cyclelogistics project; 2013 [cited 2016 Jul 27]. Available from: http://www.cyclelogistics.eu/docs/111/D2_1_Analysis_of_Cargo_Cycling_v_2_Sept2013.pdf

30. Estupiñan N, Santana, Manuel, Palacios A, Rodríguez, Daniel A. Motorcycle Ownership and Use: The case of Latin America. In Santiago de Chile; 2012. Available from: http://www.academia.edu/3856834/Motorcycle_ownership_and_use_The_case_of_Latin_America_Nicolas_Estupinan_et_al

31. Hagen JX, Pardo C, Valente JB. Motivations for motorcycle use for Urban travel in Latin America: A qualitative study. Transp Policy. 2016 Jul;49:93–104.

32. Pardo CF, Hagen JX, Burbano Valente J. Entrevistas sobre motociclistas en América Latina – informe final adenda. 2012.

33. Vasconcellos EA. O custo social da motocicleta no Brasil. Rev Transp Públicos–ANTP Ano. 2008;30:31.

34. Creswell JW. Qualitative inquiry and research design: Choosing among five approaches [Internet]. Sage; 2012 [cited 2015 Nov 9]. Available from: https://books.google.com/books?hl=en&lr=&id=Ykruxor10cYC&oi=fnd&pg=PR1&dq=Cresswell+research+methods.&ots=4bl7kHq6Hj&sig=NT3YEdvjyFyCLdExgaUq2Nkv-Rg

35. Beirão G, Sarsfield Cabral JA. Understanding attitudes towards public transport and private car: A qualitative study. Transp Policy. 2007 Nov;14(6):478–89.

36. Huth V, Füssl E, Risser R. Motorcycle riders' perceptions, attitudes and strategies: Findings from a focus group study. Transp Res Part F Traffic Psychol Behav. 2014 Jul;25:74–85.

37. Lacerda J. Bicicletas a serviço das empresas - Transporte Ativo [Internet]. 2016 [cited 2016 Jul 27]. Available from: http://transporteativo.org.br/wp/2016/07/26/bicicletas-a-servico-das-empresas/

38. do Valle Costa C, Fróes C, Hudson M, Menezes S, Mesquita VH, Andrade AJ, et al. Plano de ação para redução de emissões de gases de efeito estufa da Cidade do Rio de Janeiro [Internet]. 2011 [cited 2016 Aug 1]. Available from:

http://portalgeo.rio.rj.gov.br/estudoscariocas/download%5C3060_Plano%20de%20a%C3%A7%C3%A3o%20para%20redu%C3%A7%C3%A3o%20de%20emiss%C3%B5es%20de%20gases%20de%20efeito%20estufa%20_mar_2011.pdf

39. Camargo A. Lei Ordinária [Internet]. 5248/2011 Jan 27, 2011. Available from: http://mail.camara.rj.gov.br/APL/Legislativos/contlei.nsf/f25edae7e64db53b032564fe005262ef/5cb7185d3c0ecda1832578250070fb60?OpenDocument

40. Wood G. D2.4 Feasibility study; screening of communal and small trade services [Internet]. Cyclelogistics project; 2013 [cited 2016 Jul 27]. Available from: http://www.cyclelogistics.eu/docs/111/D2_4_Communal_Services_v3_Sept_2013.pdf