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Digital civic engagement, open data, and the informal sector: a think piece

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ABSTRACT

Digitalization and advances in information and communications technologies (ICT) are having a major impact on urban transport and the way people move around cities. However, this hardly relates to informal transport in the global South. Despite its importance and the fact that billions of people depend on it, insufficient efforts have been made by policymakers to improve informal transport services. In this think piece, we propose that this circumstance can be addressed on two counts through digital civic engagement and open data. In the digital age, civic engagement is no longer only associated with voluntary work at community level, but it is also very effective remotely. Digital civic engagement leverages social media to create awareness for in-situ concerns and provides a platform for local volunteers to connect with international experts to create people-centered solutions (e.g., mobile apps). Open data stimulates and facilitates digital civic engagement, which, in turn, can lead to the creation of more open data. Cities and local authorities should encourage and foster this virtuous cycle, and make transport data sets openly available. This can spur innovation and promote sustainable mobility behavior – with volunteers being powerful agents driving these efforts. Indeed, the case of the Trufi Association demonstrates that open data (e.g., in the form of volunteered geographic information) and the development of mobile apps in several developing cities have helped make informal transport more visible and transparent. The insights from the informal transport field can serve as an impetus for other sectors of the informal economy – such as retail, commerce, agriculture, manufacturing, and services – to promote digital civic engagement and open data to bring about positive change.

1. Introduction

Approximately 6.5 billion people – the vast majority of the world population – live in low- and middle-income countries of the global South, where rapid urbanization is observed (World Bank, 2020a). According to the World Bank, the share of urban populations has increased from about 40 % in 2000 to more than 51 % in 2020 (World Bank, 2020b). This trend is expected to continue in the future and poses major sustainability challenges for cities and metropolitan areas.

One of the most crucial challenges, thereby, concerns the mobility of people. While many of the most congested cities worldwide are located in the global South (TomTom, 2021), developing cities are increasingly facing transport-related problems such as deteriorating environmental conditions, safety and security concerns, and unequal access to transport systems (Gwilliam, 2003). With regard to the latter, inequality

disproportionately discriminates against the mobility of lower-income groups (Bautista-Hernández, 2021). Considering relatively low vehicle ownerships and the lack of mass transit infrastructure, the lower-income groups often rely on informal transport services that often represent the most dominant travel mode, along with active transport (bicycling, walking, etc.). Informal transport is typically made up of small-sized vehicles (e.g., local minibuses, vans, taxis, three-wheelers, and motorcycles) owned by individuals and operated without official endorsement (i.e., without issuing of licenses or any kind of regulation) (Cervero and Golub, 2007). According to the *Global Partnership for Informal Transportation*, “these systems move billions and provide livelihoods for millions of people.” (Global Partnership for Informal Transportation (GPIT), n.d.). Indeed, informal transport is an integral part of the informal sector, whose activities account for a significant portion of the global South’s economies, and thus open up a wide range of economic

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opportunities for people (Muchie et al., 2017). On the one hand, informal transport provides mobility for (the majority of) people to access jobs, education, and other opportunities, and on the other hand, a livelihood for countless own-account transport workers. Agbiboa (2020), accordingly, attributes informal transport a central role to urban economies and the production of new city forms. The authors of this think piece agree with this view and highlight informal transport's importance in efforts to actively counteract increasing motorization and auto centric developments.

Nevertheless, authorities tend to blame informal transport operators for traffic and safety issues (Regmi and Pojani, 2022; Rizzo, 2011). Instead of stigmatizing informal transport and seeing it as part of the problem, the goal should rather be to improve informal transport, integrate it with public transport, and harmonize it with the overall transport system (Ferro et al., 2013; Regmi and Pojani, 2022). Previous work of the first author highlights the existing demand for such integrated services and the enormous potential benefits (e.g., increased reliability and accessibility) these systems harbor (Hasselwander et al., 2022a; Hasselwander et al., 2022b).

The informal transport sector is often overlooked in public policy and planning and disproportionately discriminated against in terms of access to funding (UITP, 2021). Similarly, the amount of scientific literature on informal transport is disproportionately small relative to its role in the developing economies. Although the body of knowledge has been significantly growing in the past decades (see Behrens et al., 2021 for a recent bibliometric analysis) with some considerable research achievements (e.g., Cervero, 2000; Cervero and Golub, 2007; Horn et al., 2021; Rekhviashvili and Sgibnev, 2020), the authors of this think piece argue that more research on informal transport is urgently needed.

Therefore, this work – written as a think piece – aims to draw attention to the informal transport sector and outline ways how it can benefit from bottom-up initiatives. Specifically, we look at the potential role of digital civic engagement and open data, and how these ingredients can spur innovation and bring about positive change in the informal transport sector. We use the case of the *Trufi Association*, an NGO focusing on informal transport in the global South, to exemplify how digital civic engagement and open data have helped make informal transport services visible and more transparent through mapping routes and developing multimodal journey planner apps.

By discussing the activities in multiple characteristic cities in developing countries in which the *Trufi Association* is active in, this paper provides preliminary insights on civic engagement in transport, a topic that has been largely neglected by scholars (Stanley and Vella-Brodrick, 2009). Our focus includes small- and medium-sized cities in the global South – such as Tétouan (Morocco) and Duitama (Colombia) – that are often overlooked in the literature. We also contribute to the incipient body of knowledge on innovation in informal economies (Muchie et al., 2017) and discuss the role of open data in transport (Kuhn, 2011), all in developing context.

2. Background

2.1. Civic engagement

Civic engagement (or civic participation, also community engagement/participation) can be described as “ways in which citizens participate in the life of a community in order to improve conditions for others or to help shape the community’s future” (Adler and Goggin, 2005, p. 241). The term is often associated with young people participating in voluntary work or local community service (Adler and Goggin, 2005). In fact, however, it involves all age and social groups, and includes a wide variety of interests and motivations for participation (Hashagen, 2002). Gender differences in civic engagement vary across world regions and heavily depend on structural social factors (Brandtzaeg, 2017). Furthermore, studies found that females are more often involved in humanitarian aid and social movement-related activities,

while males are rather active in political participation (Brandtzaeg, 2017).

Civic engagement can take the form of communities working together or (a group of) individuals working alone, involves passive, reactive, and proactive measures, as well as both political and non-political actions (Hashagen, 2002). A relatively new form of engagement – often enabled through online platforms – involves networking of individuals willing to share their skills and expertise or to give feedback without expecting a financial compensation (Asdourian and Zimmerli, 2015).

Scholars highlight the importance of civic engagement, for example, as a pathway to more sustainable futures (Hashagen, 2002; Portney, 2005), for public health and well-being (Goth and Småland, 2014), or to foster innovation (Hartmann et al., 2016). Civic engagement (or the lack of it) is sometimes used as an indicator of social inclusion (or exclusion) (Stanley and Vella-Brodrick, 2009). Indeed, it is argued that civic engagement is an effective tool to give a voice to marginalized and disadvantaged groups in the community and make society aware of social ills (Stanley and Vella-Brodrick, 2009). On the other hand, Diehl and Chan (2021) found that the lack of influence on political decision-making and the perceived lack of relevant issues are the main barriers that prevent civic engagement.

There are plenty examples of good practices regarding civic engagement and participation in the context of transport (e.g., *1000 Friends of Oregon*,¹ *Walk Bike Nashville*,² *Séptima Verde*,³ *Move As One Coalition*⁴) that typically advocate for greener and more inclusive transport. However, although the importance of civic engagement is generally acknowledged in the transport arena (Sutcliffe and Cipkar, 2017), scientific publications in this field are rather scarce. Case studies have demonstrated the effectiveness of civic engagement, for example, in the context of transport planning, formulating transport policies, and collecting feedback to improve public transport services (e.g., May and Ross, 2018; Sutcliffe and Cipkar, 2017). Other activities relate to volunteered geographic information (VGI), such as mapping of transport routes or collecting information for navigation or routing services (Coleman et al., 2009). In developing countries, as described in Sunio et al. (2021), social movements have been formed to call attention to transport related inequalities. Chan and Zhou (2022), moreover, highlight the role of grassroots transport initiatives as part of wider social movements (i.e., the anti-Extradition Law Amendment Bill Movement in Hong Kong) and show how ICT and mobile apps can be utilized to mobilize citizens in times of disruptions. In many cases, social media has been exploited to enable quick communication, to increase awareness, to leverage on the worldwide reach of the internet, and to organize and magnify the movements' advocacy.

As the above examples highlight, digital technologies have enabled a new form of civic engagement (hereafter: *digital civic engagement*) which has proven to be very effective in the transport field. However, it requires access to technology as well as digital skills, which at the same time constrains the participation of certain population groups (Cho et al., 2020). A digital divide might notably be observed in countries with a large gap between rich and poor and where only scattered ICT infrastructure is available (Wamuyu, 2017).

2.2. Open data and the role of transport authorities

The advent of open data – of which transport data is just one of many sources – is believed to have enhanced urban sustainability and quality of life (Wey and Huang, 2018). In addition to traditional transport data sources (e.g., GPS), open data is often generated through mobile phone

¹ <https://friends.org/transportation>.

² <https://www.walkbikenashville.org/>.

³ <https://www.septimaverde.gov.co/>.

⁴ <https://twitter.com/moveasonepth>.

data and other alternative sources that provide insights on travel patterns and mobility behavior. Trip planning applications utilize open data to provide travel alternatives on how to get (in the most efficient way and under consideration of different transport means and modes) to a specific destination. Open data also enables various opportunities to improve transport planning, to analyze policies, and to advocate for service improvements (Colpaert and Rojas Melendez, 2019). Moreover, open data is an important resource to explore and characterize current and historical service levels or to forecast operations in the immediate future (Kuhn, 2011), and it can also be reused in the context of hackathons or app competitions to solve specific problems or address stated topics. Indeed, by opening and making transport data available, governments and transport providers enable citizens to transform data into value and create useful services for the public (Hartmann et al., 2016). Open data in transport can thus be considered as a vital resource to foster digital civic engagement and participation and to create people-centered solutions (Hartmann et al., 2016). In this context, case study results from Singapore confirm that once resources and opportunities are made available, citizens are more likely to engage in civic activities (Diehl and Chan, 2021).

On a bigger picture, the framework through which the open data movement is normally considered assumes that the government plays some role in the process, as analyses from open data initiatives show (Kassen, 2017; Barber and MacLellan, 2019). Open data initiatives are often thought of as a subset of the open government concept, and hence as resulting from political and socioeconomic initiatives that are perfectly aligned with the government's objectives. These types of initiatives are typically government driven and top down, rather than citizen driven and bottom up (Kassen, 2013). The question that naturally arises is the effectiveness of open data as a driver of civic engagement in the absence of governmental engagement.

In practice, governments and transport authorities often do not follow open data policies due to the lack of training and/or opposition to share data, or the data simply does not exist because there is no capacity to collect the data. This significantly hampers transport innovations and particularly the development of mobility apps (Colpaert and Rojas Melendez, 2019; Hasselwander and Bigotte, 2022). According to Colpaert and Rojas Melendez (2019, p. 215), "[o]nly a fraction of the data used to drive mobility apps is truly open." Several reasons contribute to why data is not made available including privacy concerns or the lack of institutional capacity in governments to manage information (Hasselwander and Bigotte, 2022; Martin, 2014). There is also the question of competitive advantages that public transport operators gain from their data sets. Even in markets that have theoretically been opened to competition, incumbent operators often maintain a monopoly over the data (Raper, 2016).

2.3. The informal transport sector

Informal transport is a global phenomenon. However, there is no generally accepted definition; informal transport is often synonymously referred to as paratransit, popular transport, intermediate public transport, and so forth. Indeed, these terms comprise different transport services in different parts of the world (mainly in the global South) that differ greatly in terms of operational and organizational setup. For instance, consider the *jeepney* (local minibus) and *habal-habal* (motorcycle taxi) in the Philippines. While the former operates on fixed routes with predefined fares, for the latter both the destination and fare are negotiable. While informal transport thus comes in many shapes and forms, some common characteristics are described in the literature (e.g., Cervero, 2000; Cervero and Golub, 2007; Horn et al., 2021), which are also relevant for the cities under investigation (i.e., Duitama, Tétouan, and Medan) in this study. Accordingly, we consider informal transport as services that

- emerge where service voids are left unfilled by formal public transport operators,
- mainly serve the poor,
- have little to no public sector regulation,
- depend on private sector initiatives,
- are owned and operated by private freelancers, and for which
- no official documentation and travel information are available.

Indeed, informal transport typically emerges where formal public transport services and infrastructure are unavailable or insufficient, and whenever excess demand enables a profitable operation. In many cases, this concerns low-income, informal neighborhoods and rural and remote communities (Horn et al., 2021). Although informal transport therefore provides mobility to a majority of the population, it is typically not endorsed or licensed by local authorities. The lack of regulation often results from financial restrictions of local governments, but it is also – as the authors of this think piece argue – a product of non-prioritization. For example, in Douala, Cameroon, informal transport is the most dominant transport mode, while the municipal bus network only accounts for 1 % of trips in the city. Yet it is the latter that is the focus of a huge public investment funded predominantly by the World Bank (Mbodiam, 2022).

As a result, informal transport is characteristically driven by bottom-up entrepreneurship; most vehicles are owned and operated by single individuals. This highly individualized operator landscape – although drivers are often organized in drivers' unions and associations, helping them uphold their interests – impedes the introduction of changes and reforms in the informal transport sector (Ferro et al., 2013). The lack of subsidies and the need to return profit, furthermore, can result in operators prioritizing services on popular routes and during peak hours (Cervero and Golub, 2007).

One potential barrier that nowadays is still hindering citizens from using informal transport relates to the paucity of available travel information (Medeiros et al., 2018). Informal transport services often operate without official stops, routes, timetables, and so forth. Also, travel information – routes and schedules – is often not published in an accessible form (if it exists at all) and is therefore only communicated through word of mouth. However, citizens in developing cities with the means to do so often prefer to plan, book, and pay trips online through mobile apps to the extent that these options are available. Mobile apps (or services such as SMS for basic phones) could make informal transport services more attractive and thus induce a modal shift – from private, low-capacity modes to public, high-capacity modes (Hasselwander et al., 2022a). For more insights on mobile apps' ability to promote sustainable mobility, we refer to a review by Andersson et al. (2018).

There are numerous initiatives in the developing world that follow the mission to improve and make informal transport services 'visible', such as *Jungle Bus*,⁵ *Sakay*,⁶ *GoMetro*,⁷ among others. These initiatives typically map informal transport routes and make travel information available through multimodal journey planner apps. To the best of our knowledge, these initiatives – including their role in and contribution to society and transport systems – have been widely overlooked in the literature so far. An important contribution has been made by Williams et al. (2015) and Klopp et al. (2017) that describe the implementation of *Digital Matatu*⁸ in Nairobi, Kenya. The studies highlight the strengths of bottom-up approaches and show how mapping informal transport and making the data openly available can improve services and spur innovation (Klopp et al., 2017; Williams et al., 2015). While the *Digital Matatu* project stemmed from an academic initiative, in the next section

⁵ <https://junglebus.io/>.

⁶ <https://sakay.ph/>.

⁷ <https://gometroapp.com/>.

⁸ <https://digitalmatatus.com/>.

we describe a similar initiative – the *Trufi Association*⁹ – that was entirely established through voluntary efforts.

3. Case study: the Trufi Association

The *Trufi Association* (hereafter: *Trufi*) is an international, non-profit NGO founded in 2018. It is registered in Germany and follows the mission to improve informal transport in cities of the global South. An overview of the developing cities in which *Trufi* is active is shown in Fig. 1. For its projects, *Trufi* mainly builds on voluntary work and donations. Over the years, about 100 volunteers have been involved in their activities, some of which only have been active for a certain time or only in specific projects. Currently, there are about 40 active volunteers. *Trufi*'s main product is a multimodal journey planner (*Trufi app*) that has been launched in several developing cities so far – localized for each city with a unique app name, and a user interface translated to widely used local languages.

The use case of the *Trufi app* is very different from that of journey planner apps in developed cities. In the words of the lead developer of the *Trufi app* – who is from Bolivia but currently lives in Germany – journey planner apps in developed cities such as Hamburg provide detailed travel information including departure and arrival times for unique or daily trips. Since timetables are not available in developing cities such as Cochabamba, Bolivia, journey planner apps for informal transport services mainly help users how to get to unfamiliar places by giving information about which minibus (known, in Cochabamba, as *trufis*) to take, where to make a transfer, etc. Considering that the *trufis* represent the most dominant travel mode in Cochabamba, one can expect that there is huge demand for this kind of digital travel information. Indeed, with currently more than 25,000 users (both on Android and iOS), the *Trufi app* – which first launched in 2019 – is enjoying great popularity especially since receiving an unsolicited endorsement in a viral social media video (Johnson, 2022).

Building on the project from Cochabamba, the *Trufi app* has been made available open-source as a white label solution that can be replicated by anyone and customized to different local contexts. At the same time, *Trufi* also leverages other open technologies such as *Flutter*, *OpenTripPlanner*, and *OpenStreetMap* (OSM). Besides providing the open-source code and step-by-step instructions for building the app, *Trufi* offers support and guidance within the whole process from the first steps to the official release. This includes collecting informal transport route data and importing it to OSM, retrieving virtual schedules (in GTFS format), and customizing and extending the app.

There are some projects that have been realized through external funding, for example, in Nouakchott, Mauritania. For the purpose of this research, however, projects that have been initiated and implemented through voluntary work are of particular interest. In addition to the eponymous project in Cochabamba, this also refers to the projects in Duitama (Columbia/Latin America), Tétouan (Morocco/Africa), and Medan (Indonesia/Asia) on which we focus on in our analysis. In this context, we conducted semi-structured interviews (32:50 min./Duitama, 36:46 min./Tétouan, 37:43 min./Medan) with the respective project initiators. We further need to mention that the authors of this paper have been involved in voluntary work for *Trufi* for several years and that we are very familiar with the above-mentioned projects including the involved persons. Hence, this means that our discussion also strongly builds on insights from auto-ethnographic accounts (Chang, 2016). More specifically, we can draw on e-mail and personal communication with other volunteers as well as involved stakeholders (e.g., city officials, transport authorities, development aid agencies, etc.), team meetings, and general project work. We also have access to the organization's *Slack* channel which is used as the main platform for internal exchange and documentation. In addition to this, an online

survey has been conducted in February and March 2022, which has been completed by 27 *Trufi* members.

We use the available data sources to conduct a preliminary analysis using methods for building theory from cases (Eisenhardt and Graebner, 2007). Based on the results, we forward tentative propositions on how digital civic engagement and open data can benefit informal transport.

4. Results and discussion

4.1. Who gets involved in digital civic engagement and why?

Table 1 shows the descriptive profile of respondents of the survey. Considering the small sample size, we have to mention that it only provides preliminary insights on the characteristics of volunteers engaged in digital civic engagement.

Despite the focus on global South cities, about half of the respondents are based in the global North. This is not surprising considering that *Trufi* is a German NGO and that similar results have been observed for other volunteering projects (Neis and Zipf, 2012). Notwithstanding, this highlights that remote civic engagement is not only possible, but effective. Accordingly, the vast majority of respondents have been involved in remote international projects (Table 2). The direction of remote work is thereby not only from the global North to the South, as one could expect, but also across different regions of the global South. For example, programmers and mappers from Bolivia have supervised and contributed to the project in Tétouan, Morocco. The developer of the *Corsa* app in Tétouan then advised the volunteer of the project in Medan, Indonesia.

There are recognizably more male volunteers involved in *Trufi* activities compared to female volunteers¹⁰. Several factors are expected to contribute to this circumstance. For example, much of *Trufi*'s work is related to activities that are traditionally rather male-dominated (e.g., programming, mapping in OSM) (Das et al. 2019; Rubio et al., 2015; Schmidt and Klettner, 2013). However, the authors expect that structural social factors such as parental roles (Brandtzaeg, 2017) and the digital exclusion of women (Törenli, 2006) – particularly in the global South – also contribute to the gender gap observed in this type of civic engagement.

The survey results confirm that not only young people are involved in digital civic engagement. While volunteers aged 26 to 35 are the strongest represented age group (33.3 %), none of the respondents was younger than 18 years old. The latter is quite surprising, given that school students nowadays appear to be very active in civic activities and particularly get involved in pro-environmental activism (Wallis and Loy, 2021) and digital civic engagement (Cho et al., 2020). Considering that transport-related GHG emissions are growing rapidly (especially in developing countries) (Lamb et al., 2021) and that mobility is one of the most effective individual leverage points to address anthropogenic climate change (Wynes and Nicholas, 2017), the generation of young, environmentally concerned people are a promising target group for digital civic engagement in the transport field that need to be better integrated in such projects.

It is striking that respondents with a university degree are highly overrepresented (77.8 %). Due to the correlation of education and income (Gregorio and Lee, 2003), one can expect that rather wealthy people are involved in this kind of civic engagement (note, however, that income levels have not explicitly been surveyed). Unsurprisingly, this stresses that digital civic engagement is prone to excluding certain population groups and that complementary activities are needed to get these people involved.

The majority of respondents have been active with *Trufi* for more

⁹ <https://www.trufi-association.org/>.

¹⁰ Note that due to the small sample and the skewed gender distribution, we did not ask for the respondents' gender to avoid identifiable constellations of responses.



Fig. 1. Map of cities in the global South in which the Trufi Association is active as of July 2022.

Table 1
Descriptive profile of respondents (N = 27).

Survey question	Response	%
Where are you based?	Europe	48.1
	North America	3.7
	South America	22.2
	Africa	22.2
	Asia	3.7
How old are you?	18–25 years	29.6
	26–35 years	33.3
	36–45 years	25.9
	46–55	3.7
	56+	7.4
	What is your highest degree / level of school?	High school
Trade/technical/vocational training		7.4
Undergraduate (e.g., bachelor's degree)		44.4
Postgraduate (e.g., Master or PhD)		33.3
What is your (main) occupation?	Student	18.5
	Professional/Self-employed (full-time)	51.9
	Working part-time	18.5
	Unemployed	11.1

Table 2
Characteristics of respondents' voluntary work (N = 27).

Survey question	Response	%
How long have you been volunteering for Trufi?	Less than 1 year	44.4
	More than 1 year	14.8
	More than 2 years	25.9
	More than 3 years	7.4
	More than 4 years	7.4
In what times of projects have you been involved?	Local projects (in your home country)	29.6
	International projects (remotely)	14.8
	Both local and international projects	55.6
Is your Trufi work related to your main occupation?	Yes	55.6
	No	44.4
Are you currently involved in other voluntary work?	Yes	66.7
	No	33.3

than one year (Table 2), some even since the inception of *Trufi*. Many *Trufi* volunteers, especially those based in the global North, are involved in administrative activities that are not limited in time (e.g., HR, marketing and communications). These volunteers often bring in expertise from their professional life. Indeed, the majority of respondents (55.6 %) state that their work at *Trufi* is related to their main occupation. This usually also relates to volunteers that take over more technical tasks, particularly related to programming. For these people, the voluntary work at *Trufi* represents a great way to apply their knowledge, strengthen their skills, and exchange with other experts in the field. Another major group of volunteers is represented by those associated with or interested in development work and the (informal) transport field. For them, volunteering at *Trufi* is often seen as an opportunity for networking, to increase the impact of their professional work (if it is related), and being updated on the latest developments in the field. Finally, there is also a fair number of researchers among the volunteers, whose research field is somehow related to the work of *Trufi*. These volunteers are often motivated by getting insights into real-world applications, contacts to practitioners, and access to data (Fig. 2a).

Most of the volunteers from the global South are based in countries with ongoing local projects. Many of them – including the developers of the Tétouan and Medan apps (Table 3) – were motivated by their own negative experiences with informal transport. Hence, they expressed the desire to improve the livelihoods of their local community, create something meaningful, and contribute to society. Indeed, according to the founder of *Trufi*, the project arose out of the pain points of using informal transport services with the intention to provide a remedy, which is a common motivation for open-source initiatives (e.g., Raymond, 1999).

The respondents associate positive sentiment with their voluntary work, often mentioning that it is their passion and what they love. At the same time, many of them appreciate that volunteering is a great way to meet new people and that it can open up opportunities in their working lives (Fig. 2b). It was further found that two-thirds of respondents are also engaged in other voluntary work, which suggests that strong social commitment and idealistic aims are reasons for involvement in digital civic engagement.

These preliminary findings lead to our first proposition.

P1: *Volunteers in the informal transport sector do not necessarily have to live where these services are available, nor do they need to be frequent users of the services. Rather, the motivating force is the opportunity to contribute to a greater cause with their personal/professional skills –*

Table 3
Overview of project development.

	Duitama, Colombia	Tétouan, Morocco	Medan, Indonesia
Project name and launch date	BusBoy App; 2019	Corsa App; 2021	Tbd; forthcoming
Volunteer description of project initiator	Middle-aged high school teacher from Duitama	Undergraduate computer science student in his early twenties based in Barcelona, Spain	Undergraduate computer science student in his early twenties based in Medan, Indonesia
Transit system description	Semi-formal bus network: 22 routes and 3 operators	Semi-formal bus network: 24 routes, 519 stops, and 1 operator	Dense minibus (<i>angkot</i>) network, only few bus routes
Trigger for voluntary activities	As part of a school project, the high school teacher and his students (aged 8 to 16) started mapping and maintaining the city's public transport network. With the help of foreign NGOs, they expanded the mapping project and built the journey planner app for their city.	After returning to Tétouan after a couple of years absence, the volunteer found it difficult to navigate the local bus routes. During the semester break at university, he therefore decided to apply his computer science education to single-handedly map the entire bus network and develop the journey planner app.	The volunteer grew up in the city of Medan, and from the age of 15 used the <i>angkots</i> daily to go to school. He was interested in developing an app and thus made some proposals for coursework assignments. Due to the positive feedback by his professors, he decided to pursue the app development as part of his thesis completion requirement. He manually mapped 70 <i>angkot</i> lines with a GPS tracker. He is currently trying to convert the GPS data into GTFS, a process that should take about two weeks.
Data collection procedure	The group of volunteers mapped the bus networks in a single day. Afterwards, they converted the GPS tracking data into OSM relations over a series of weekends.	He first downloaded timetable information from a third-party source, then combined it with bus routes that he drew on OSM. Finally, open-source tools were used to convert the data into the necessary GTFS format.	He manually mapped 70 <i>angkot</i> lines with a GPS tracker. He is currently trying to convert the GPS data into GTFS, a process that should take about two weeks.
Interactions with open-source software and open data throughout the process	A Github page containing the itinerary calculator's code was the foundation of the app that was developed.	Bus routes were available free of charge on the internet. An open-source tool was used to convert bus routes to GTFS. A Github page containing the itinerary calculator's code was the foundation of the app that was developed.	Prior to working with this project, he was engaged with multiple open-source projects. He received free training on how to use several open-source tools.
Support of local stakeholders	Local bus companies allowed volunteers on board their buses for free to track the routes. One local operator continued to provide information on route changes after the mapping.	Local authorities have not been supportive. However, a manager at the bus company directed him to an alternative source when he inquired about the bus data.	He received a letter of introduction from the university to the local transport operators.

Due to these activities, *Trufi* and its approach as well as its successful implementations have gained some attention. This has helped to acquire some paid projects both in the global North and South that are cross funding overhead expenses and costs (e.g., costs related to hosting the website and the apps, and some paid part-time jobs) of the volunteer-initiated projects. For instance, based on the *Trufi* core initially developed for Cochabamba, multimodal journey planners for the municipalities of Herrenberg, Ludwigsburg, and Pforzheim, all in Germany, have been implemented. Making further use of the open-source code, as part of different hackathons, an app for combining bicycle trips with public transport has been developed for the city of Hamburg and an app for barrier-free routing (for people with reduced mobility) for the federal state of Baden-Wuerttemberg.

Similarly, *Trufi* has also worked together with international donors – mainly development organizations. For instance, the World Bank – which has been actively supporting open data efforts in developing countries for many years (World Bank, 2017) – has funded a project in Nouakchott, Mauritania to map the local public transport network. There are also currently discussions to build a bike app for the city of Quito, Ecuador. An open-source application such as the *Trufi* core is thereby explicitly desired. New features to be developed are the tracking of bicycle trips and the possibility for cyclists to rate trip segments. In the long term, the app would thus create publicly available insights on the availability and quality of cycling infrastructure in the city.

Another example show that volunteers indeed make use of these type of open data. In 2017, the Agence Française de Développement (AFD) financed the collection of public transport data in Accra, Ghana to support transport planning. Hence, over 300 routes were created in OSM as well as the respective GTFS files. *Trufi* volunteers then reached out to the local open data community in Ghana and offered to work together to develop a journey planner app based on the available data and the *Trufi* core. Led by a Bolivian developer, the app (*Trotro* app) was then successfully implemented and launched in 2019.

The above discussions lead to the following propositions.

P2: Making data openly available opens multiple a venues for digital civic engagement – opportunities to use, maintain, and develop the data. This creates a virtuous cycle in which more open data leads to more digital civic engagement, and vice versa. In this way small initiatives in the informal sector turn into long-term projects.

P3: Successful digital civic engagement initiatives that focus on open data and open-source empower local entrepreneurs, but also attract the attention of municipalities, government agencies, and development aid organizations, among others, to fund and support these initiatives. Herein lies an opportunity for the informal sector to receive the attention needed for sustainable improvements.

5. Conclusion and future research directions

This research has looked into the question of how the informal transport sector can benefit from digital civic engagement and open data. For this purpose, we analyzed the case of *Trufi*, a non-profit NGO that connects local volunteers with international experts to make informal transport services more transparent through journey planner apps. While *Trufi* started as a local project in Bolivia, after making the source-code openly available and informing about the *Trufi* approach (i. e., how to map and collect informal transport data and customize the app), it grew into something bigger. Local entrepreneurs in different areas of the developing world took matters into their own hands to create people-centered solutions for their cities. We thereby found that voluntary activities that create open data (i.e., the collection of VGI) inspire additional activities at the ‘adjacent possible’ (Björneborn, 2020), in this case the development of the journey planner app. Throughout this process, the local entrepreneurs also benefited from the greater collective of international volunteers that helped them to

implement and maintain the app.

The relationship between open data and volunteer activities is expected to create positive rebound effects, as described in the literature. If indeed volunteering in open data projects leads to skill development, enjoyment, and sometimes eventual monetary rewards (Budhathoki and Hawthornthwaite, 2013), it stands to reason that volunteers would find it attractive to spend more time on their projects. On the other hand, having a large pool of volunteers contributes to faster problem-solving (Raymond, 1999) and seemingly a final product that sees a greater level of demand (Krishnamurthy, 2002). It also stands to reason that this kind of work would be incredibly sustainable and resilient to changes in the external economic environment.

For policy and practice, it is therefore crucial to understand who the potential volunteers are and how to get them involved in these kinds of projects to trigger voluntarism in the informal sector. Our survey of *Trufi* volunteers gives preliminary insights in this regard: the volunteers are predominantly male, have a high formal education, and demonstrate strong digital literacy. We further found that they have manifold motivations to participate in digital civic engagement including professional or personal interest, as well as altruistic reasons. They also take a variety of different paths into the field, as we saw through the diverse experiences of the volunteers that we interviewed. However, the common denominators for volunteers to develop the apps in the cities under study (Duitama, Tétouan, and Medan), are previous negative experiences with informal transport and the desire to improve it.

We also found that some population segments are under-represented in the *Trufi* project, which naturally opens the question of how they can be involved in digital civic engagement activities. The first segment relates to marginalized citizens without access to the internet. To counteract a digital divide, it is therefore crucial that traditional civic engagement projects are not replaced. Also, remote activities should always be combined and supported through the work of local NGOs on the ground. The second segment relates to young, environmentally concerned citizens. To better integrate them, it requires effective and easy-to-use civic technology platforms (May and Ross, 2018), a better communication of the projects' goals (e.g., promoting sustainable mobility behavior and reducing GHG emissions), and initiatives at local schools as demonstrated in the Duitama project. Finally, to increase the share of female volunteers in the digital space, structural changes are needed. The foundation for this is an equal access to school education, but also initiatives such as *she codes*¹¹ – that aim to help females integrate into and advance in programming and digital technologies – are needed.

Regarding the role of open data, the *Trufi* case shows that the lack (or unavailability) of open data from local authorities do not necessarily discourage digital civic engagement activities. Instead, volunteers are willing to collect the required data themselves and make it publicly available for the use of others. By doing so, besides receiving support from other volunteers, they particularly benefit from other available open-source materials such as source codes and software. This suggests that open data indeed drives digital civic engagement initiatives, which, as in the case of *Trufi*, can create additional open data. While governments should therefore publish open data (if available) in the first place to raise awareness and spark local initiatives, open-source projects can be seen as blueprints that support the dissemination of ideas and best practices. Indeed, the open-source community acts as a powerful lever, multiplying the effectiveness of the work done by the rest of the volunteer community. Supporting these projects, and the communities that develop around them, is therefore an efficient way to support digital civic engagement and the generation of open data.

Overall, the present study highlights that open data and digital civic engagement can play a significant role in the transport sector. It provides insights on how these components can bring about positive change (e.g.,

through the development of mobile apps), as well as recommendations for policymakers and local authorities on how to trigger such development. The study results are transferable to other informal sectors that could benefit from open data and digital civic engagement including retail, commerce, agriculture, manufacturing, and services. Considering the novelty of this field of research, however, many questions still remain unanswered. We have forwarded three tentative propositions that should be validated in future research. In particular, we stress the need to verify the causal relationship between digital civic engagement and open data. Does the availability of one really lead to the creation of the other (as we propose in this study), or are both just the fruit of a generally open and democratic society that develops independently? We further recommend examining whether digital civic engagement and open data also trigger initiatives and/or investments in the informal sector by private actors. Also, the threat of a digital divide and the question of how digital civic engagement can be made more inclusive merits additional research. Finally, it is worth exploring whether and how the informal transport sector should be reorganized – under consideration of the (often conflicting) interests of involved stakeholders – to better integrate the use and creation of open data as well as civic engagement of local volunteers.

CRedit authorship contribution statement

Marc Hasselwander: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft. **Mwendwa Kiko:** Investigation, Formal analysis, Writing – original draft. **Ted Johnson:** Resources, Validation, Writing – review & editing.

Declaration of Competing Interest

It is acknowledged that MH and MK are involved in voluntary work for the *Trufi* Association. TJ is a part-time employee of the *Trufi* Association.

Data availability

The authors do not have permission to share data.

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¹¹ <https://www.shecodes.io/>.

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