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– ALGORITHMIC SUTURING: Platforms, Motorcycles and the 'Last Mile' in Urban Africa

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Abstract

The 'last mile' is not only a powerful metaphor of contemporary life, but also the tangible site of a challenge, whether for governments wanting to reach their citizens or companies wanting to reach their customers. In urban Africa this challenge is compounded by the fragmented material condition of cities. As a result, a growing number of tech companies have been compelled by the possibility of creating digital platforms that address the unique logistical configurations of African cities, often enrolling informal systems such as motorcycle taxis to address spatial and economic fragmentation. Through the perspective of three Nairobi-based startups that incorporate motorcycle taxis into their last-mile platforms, this article illustrates how processes of 'algorithmic suturing' knit together the loose ends of splintered urban networks thanks to platform business models that visualize the last mile as a site of optimization. In parallel with common understandings of suturing within African infrastructure debates which foreground makeshift practices of the urban poor, this article argues that algorithmic suturing is a speculative endeavour through which urban fractures are made legible as sites of value. By stitching together city fragments, these platforms envision large data-driven urban economies which interface with informal mobility networks and the shifting urban demographic of the lower-middle class.

Introduction

The 'last mile' is a powerful metaphor of contemporary life, shifting meanings across contexts and among different actors. Supply chain managers, for example, define the last mile as the ultimate leg of goods reaching their final customers, whether a transportation hub, a warehouse or an individual person (Hayes, 2021). For development technocrats in Africa the last mile refers to the distance between households and centres where public services such as healthcare are available. For telecommunication companies the last mile allows individual users to connect to the backbone of bigger communication networks. For AI scholars the last mile captures the 'ghost work' that humans need to perform when algorithms fall short (Gray and Suri, 2019).

Despite these various meanings, there is a thread running through these definitions. Consider, for example, the schematic representation in Figure 1, which accompanies the Wikipedia entry for 'last mile' (as of July 2022).[1] In the visualization, the last mile is represented by the loose ends of a networked tree. These loose ends are not just the ultimate conduits of networked systems; they are also the terminals where infrastructural grids scatter and break, where they frictionally interface with each other, and where urban splintering (Graham and Marvin, 2001) and suturing (De Boeck and

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1 Using a few examples (namely, tree trunks vs. root hairs, rivers vs. drip irrigation, interstate highways vs. back roads, and intercontinental cables vs. user internet access), the Wikipedia caption illustrates the capillary and peripheral nature of the last mile in a networked system.

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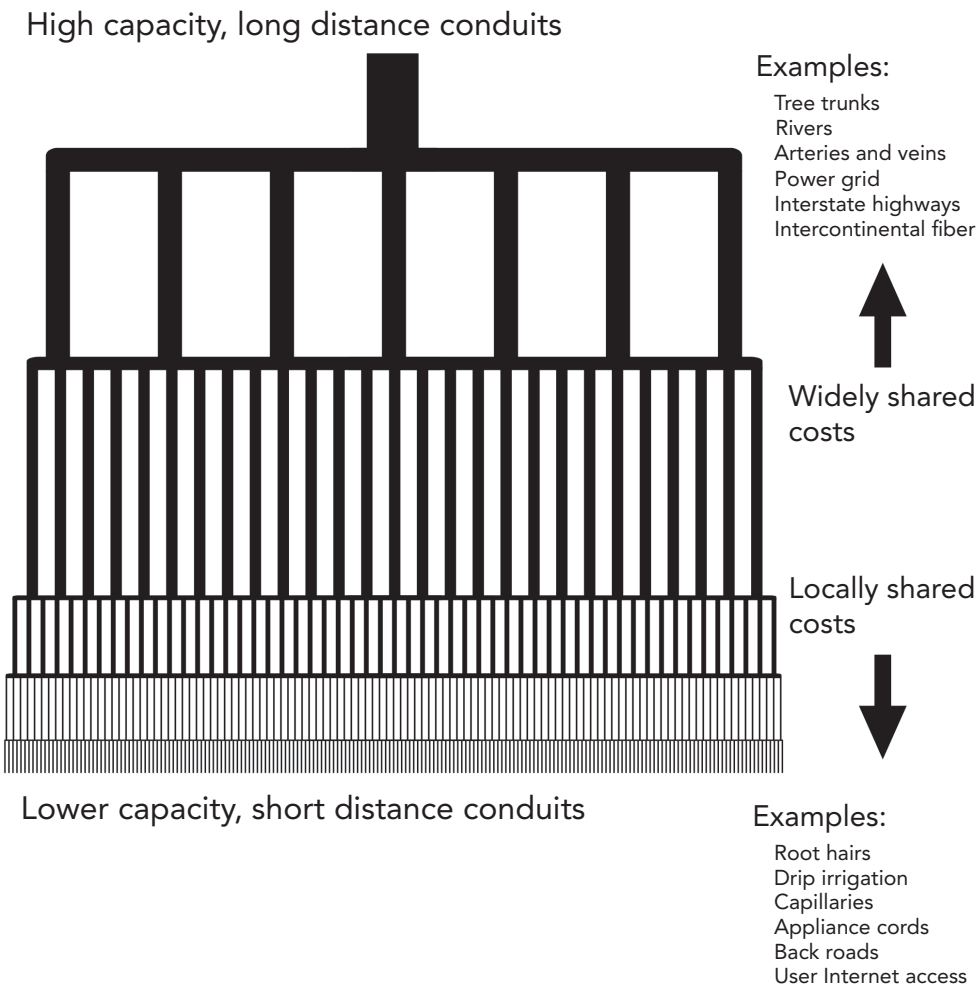


FIGURE 1 A visual representation of the last mile—the thinner lines or loose ends—in a hierarchical network (*source*: Wikipedia, from user Dycedard; no changes were made to the image: https://upload.wikimedia.org/wikipedia/en/3/32/The_last_mile_hierarchy.svg)

Baloji, 2016) become a matter of laborious coordination between different technical systems. Because of these frictions, reaching the last mile is the costliest and most challenging part of many businesses.

At a time of emerging forms of what Moritz Altenried (2019) has termed 'logistical urbanism', global platform companies are making these 'problems' of last-mile coordination their core business model: Uber with e-hailing; Alibaba with drop-shipping; Glovo with Q-commerce;[2] as well as Amazon (and many others) with their mechanical Turks.[3] In urban Africa—the setting of this article—these last-mile challenges are compounded by the fragmented material condition of cities. Low-density sprawl, under-maintained road networks, lack of addressability and fractured service

2 Q-commerce or 'quick commerce' (sometimes referred to as 'e-grocery') is the on-demand outsourcing of grocery shopping to platform workers.

3 Amazon Mechanical Turk is a platform for hiring remotely located 'crowdworkers' to perform discrete on-demand tasks. Although this is not necessarily an urban phenomenon, there is a distinct urban bias to the geographies of on-demand work.

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delivery systems express both obstacles and opportunities for the optimization of last-mile problems through digital platforms.

Building on this insight, the article focuses on startups that employ digital platforms to develop last-mile economies by incorporating motorcycle taxis into their algorithms. As in other Southern cities, in large African metropoles such vehicles are perfectly formatted for the kind of fast-paced and short-distance movements necessary to overcome spatial and economic fragmentation. They already constitute a lifeline for the mobility of people and goods where larger vehicles fail to provide sufficient capillarity. And so motorcycles have compelled both global and domestic tech companies to find ways of subsuming riders into platforms that seek to address the last-mile problem with dedicated digital solutions.

While most scholarly work on this phenomenon has rightly focused on the issue of 'platform labour' (Van Doorn, 2017), highlighting the forms of precarity and exploitation that are beholden to the digitization of mobility in urban Africa (see Pollio, 2019; 2021; Anwar and Graham, 2020; Doherty, 2020; Iazzolino, 2021; Odendaal, 2021; Anwar *et al*., 2022; Arubayi, 2021), our focus on startups deploys a different entry point. Specifically, the article charts how these fledgling companies make the 'work' of last-mile coordination legible, by visualizing the opportunities through which motorcycle taxi networks can be mobilized to address economic and spatial fractures in African cities. As detailed in what follows, we use the notion of 'seeing like a last-mile business model' (inspired by James Scott's 1998 book *Seeing Like a State*) and insights from media studies to show how startups themselves understand and make legible the last mile, as well as how we, as researchers, can methodologically encounter the last mile, not (only) as a metaphor, but as an algorithmic practice.

In doing so, we describe 'algorithmic suturing' as a key operation at the nexus of digital technologies and motorcycle taxis. Algorithmic suturing is the knitting together of the loose ends of splintered urban networks and informal economic activities through platform business models that visualize the last mile as a site of optimization and value creation. This conceptual contribution emerges from ongoing research on the platformization of two-wheel logistics in Nairobi, Kenya (Sitas *et al*., 2022). Much as in many African cities, Nairobi's motorcycle-taxis—called *boda boda*—are used to carry people, goods and parcels. They are one of the fastest ways to move through the city and form an integral part of everyday life. They generally fall into what is called 'paratransit'[4]—a blurry category that straddles public and private modes of movement and includes minibuses (usually 14- to 16-seater vans), *tuk tuks* (three-wheelers) and motorcycles. As a prosthesis to splintered network economies, *boda boda* operate where other mobility and logistics options are too costly, too cumbersome, or simply not flexible enough to address the last-mile problem. Increasingly, they do so through data-driven platforms, as will be shown in our three case studies.

Drawing from this work on Nairobi, the article makes two arguments. First, we suggest that the last mile renders the loose ends of networks legible as a problem of coordination, as a potential business opportunity, and as a key site of optimization—this is, after all, the most expensive part of global supply chains. Seeing like a last mile, which we intend here more narrowly as *a last-mile business model*, thus reveals some of the hidden scripts that algorithmically suture the city, and some of the behind-the-scenes processes of coordination through which new urban networks are given effect and substance thanks to last-mile platforms. This last-mile view also creates new 'leads'—things made visible that otherwise might not be. We highlight some of these in the conclusion—for example, the importance of the Chinese internet industry in urban Africa—in the hope that they will inspire scholars to take these emerging algorithmic economies seriously.

4 See Pirie (2014).

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Second, we argue that algorithmic suturing challenges some of the conventional notions within Southern infrastructure scholarship concerning how and by whom material and network improvisation takes place.[5] While acts of suturing are often read as a practice of urban survival at the margins of the city, last-mile business models extend this story. Platforms stitch together city 'fragments' (McFarlane, 2018), developing algorithmic interfaces between precarious workers and the growing demographic of the lower-middle class in urban Africa. This lower-middle class demographic is not a discrete category or group, but rather a market both envisioned and, in part, produced by platformed service delivery. Aspirational processes of 'middle-classing' have been addressed in the financial anthropology of African capitalism (James, 2021), yet their role in shaping urban change (Mercer, 2014; 2020) is also evident in the future-making practices of last-mile algorithms.[6]

Overall, our contribution to urban scholarship stems from a desire to produce a meso-level analysis of urban platforms, without dissolving their specificity into a frontierist critique of global technocapital's search for new profit opportunities in African cities (Ouma, 2017), nor seeking to offer a fine-grained investigation of the infrastructural labour upon which the former depend. While cognizant that these too are crucial analytical entry points, we suggest that a shift in perspective—see Qadri and D'Ignazio (2022) for a different but complementary approach to this one—or better, taking for a moment the perspective of last-mile startups, sheds light on some of the emerging urban geographies of platformization in Africa and their implications. Before moving on to these last-mile 'views', however, the next three sections provide, respectively, a description of algorithmic suturing, an overview of digitization in the *boda boda* sector in Kenya, and a detailed account of our methodological approach.

Algorithmic suturing

The concept of algorithmic suturing draws on the insight that urban life in Africa is often made possible by practices of infrastructural repair, mending and patchwork. Specifically, Filip De Boeck and Sammy Baloji use the metaphor of the 'suture' to describe the junctures and seams through which urbanites—often against all odds—find ways to 'fill the gaps, overcome the hiatus, design realignments and thereby redefine the zero … into a possibility, a something else, a surplus' (De Boeck and Baloji, 2016: 16). More broadly, it was AbdouMaliq Simone's fitting yet sometimes misunderstood notion of 'people as infrastructure' that drew attention to the machinic acts of suturing through which life is reworked and made possible in contexts of extreme disposability and precarity (Simone, 2021).

With 'algorithmic suturing' we combine this attention to the 'mathematics' of collective urban life (Simone, 2021: 1343) with an expansive definition of algorithms (Gillespie, 2014). More than just lines of code (Seaver, 2017), algorithms have a genealogy that predates digital technologies (Striphas, 2015; Daston, 2022). An algorithm is in fact 'an abstract diagram that emerges from the repetition of a process, an organization of time, space, labor, and operations', as well as 'the division of this process into finite steps in order to perform and control it efficiently' (Pasquinelli, 2019: 6). Most importantly, Pasquinelli further writes, 'an algorithm is an economic process, as it must employ the least amount of resources in terms of space, time, and energy, adapting to the limits of the situation' (*ibid*.). Moreover, as Lilly Irani explains, confining algorithms to a purified notion of software 'automation', devoid of the multiple forms of labour intrinsic to it, risks reinforcing the narrative adopted by platform companies, which essentially makes

5 On a related subject, see Cirolia *et al*. (2021), Günel (2021), Lemanski (2021), Cirolia and Pollio (forthcoming).

6 In this article we are not concerned with (nor would we have the data for) defining the sociological contours of this demographic category (the lower-middle class) but we treat it as an emic category that our informants used to describe an under-served market and therefore an opportunity for processes of algorithmic optimization.

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some forms of work invisible to the benefit of others (Irani, 2015). Put differently, algorithmic suturing also captures the limits of algorithms, in that they are themselves always in need of spatial and other fixes (Pollio, 2021).

The concept of 'algorithmic suturing' thus dovetails with two important strands of scholarship. First, as we have seen, work dedicated to understanding how, in African cities, hybrid, alternative and incrementally improvised configurations suture disrupted urban fabrics both physically and metaphorically (Silver, 2014; De Boeck and Baloji, 2016; Baptista, 2019). These scholars have also challenged the binary between networked and post-networked systems (Akallah and Hård, 2020; Cirolia *et al*., 2021), charting the strategies of 'technological bricolage' that exist on the ground (Lemanski, 2021) and stretching the ontological scope of what constitutes infrastructure (e.g. Larkin, 2004; Kimari, 2021; Simone, 2021). Second, algorithmic suturing speaks to a growing body of literature that specifically maps the patchworked nature of digital technologies in urban Africa, offering a perspective on the incomplete, piecemeal and adaptive remaking of platforms, and challenging simplistic visions of domination and leapfrogging (Guma and Mwaura, 2021; Guma, 2022; Guma and Wiig, 2022; Odendaal, 2021). This work fits into a wider body of scholarship on digital transformation and entrepreneurship in the continent (Friederici, 2018; Pollio, 2020; 2022a; Guma and Monstadt, 2021; Odendaal, 2023).

Motorcycles, algorithms and the materiality of African cities

Our focus on motorcycles as a last-mile device is not incidental. Their contribution to the movement of people and goods in Africa is vital to the everyday pulse of cities (Agbiboa, 2020).[7] Where private car ownership is a relatively new addition to the ascent of the middle class, reliance on alternative modes of movement has long been a necessity. In many African cities, motorcycles are indeed the most effective vehicle for short, fast trips. For a city like Nairobi, conservative estimates by the Boda Boda Safety Association put the number of motorcycle riders at fifty thousand (Omulo, 2021)—a total that doesn't include unregistered operators.[8] Owing to this ubiquity in Kenya's capital city (as well as in smaller urban centres) a mixture of internationally imported and locally assembled motorcycles enables a distributed mobility service that complements larger vehicles such as minibuses (locally called *matatu*[9] *and generally used by passengers for longer trips) and delivery vans (used for the movement of larger quantities of goods)*.

The modal choice of the motorcycle, particularly for last-mile transportation, is a response to the material conditions of the African city.[10] In the context of large, sprawling urban footprints, getting passengers and goods to the peripheral outskirts or to the crevices of high-density suburbs requires a fuel-efficient, agile vehicle. Such agility of movement is likewise necessary to bypass the thick traffic which clogs highways and intersections, and to overcome incomplete and under-maintained road networks (for example, navigating rutted surfaces unsuited for cars). Nairobi is a particularly fitting vantage point from which to observe this: a city splintered by early colonial plans (Ese and Ese, 2020) and contemporary large-scale bypasses (Guma *et al*., 2023), and dotted with leafy, middle-class cul-de-sacs, busy commercial malls, hyper-dense

7 The same is true in other large Southern cities too. See, for example, the work of Claudio Sopranzetti in relation to Bangkok (2013), Sam Nowak (2021) and Qadri and D'Ignazio (2022) on Jakarta, and Kevin O'Neill for Guatemala City (2022).

8 Due to the absence of an official database, the exact number is unknown, but it is likely to be much higher. The National Crime Research Centre (Opondo and Kiprop, 2018), for example, reported that 1,393,390 motorcycles had been registered with the National Transport and Safety Authority as of February 2018. The Kenya National Bureau of Statistics (KNBS, 2022) also reports that the number of motorcycles registered in 2021 rose to 285,203 from 246,705 the previous year. How many of these motorcycles are operating as *boda boda* in each city/region remains undocumented, however.

9 For a history 'from below' of this unique, embattled transit network, see Kenda Mutongi's *Matatu* (2017). An interesting visualization project of the *matatu* network is captured in Klopp *et al*. (2017).

10 *Boda boda*, as Joyce Nyairo (2023) has brilliantly explained, are also part of the making of citiness itself.

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suburbs, master-planned estates, sweeping informal settlements, warehousing precincts, and 'plotted' (Karaman *et al*., 2020; Maina and Cirolia, forthcoming) peri-urban fringes. In this context, motorcycles are a vital and rapid undercurrent. They stitch together fragmented parts of the city, hybridizing service delivery (Jaglin, 2014) and overcoming the brittle and enduring legacy of colonial planning, postcolonial projects of modern city building, and forced informality (Ese and Ese, 2020). Alongside passenger transit, motorcycles have for decades also been used for last-mile delivery, as they are not only fast but also affordable to maintain and operate—all of which contributes to reducing the supply-chain costs for logistics companies.

Despite this important role of motorcycles in urban economies, most African governments have taken punitive measures against the sector (see Goodfellow, 2015). While two-wheelers were initially conceived as a solution to austerity measures introduced for structural adjustment (Rizzo, 2002), today they are seen as an unwieldy urban industry in need of some form of regulation. However, as the riders are mostly young men, they also constitute an important political clientele. Central and local governments have therefore pursued ambivalent and contradictory practices. The most draconian of these policies have been implemented to address issues of passenger safety—measures which artificially segregate using motorcycles to move people around from using them to move and deliver goods. Conversely, efforts to modernize urban mobility generally include banning motorcycles from particular parts of cities (usually city centres), and supporting investment in large-scale transport projects such as Bus Rapid Transit (BRT) systems—both of which fail to overcome the incredible need and demand for distributed, capillary delivery and pillion services. The Kenyan government, in particular, has long turned a blind eye to the *boda boda* sector—allowing the emergence of competing and self-regulating voluntary associations—but it is now involved in a regulatory attempt that, if successful, will radically transform the industry.[11]

In this context, the tech community has been increasingly compelled by motorcycle mobilities over the last few years. This also aligns of course with a much larger trend, whereby digital innovation seeks out 'untapped' niches in city systems, looking for sites where platform solutions may be able to solve what appear to be urban problems. Some of the digital innovation sits in the e-hailing space (allowing end-users to connect to riders through mobile phone-based applications such as Uber boda or Safeboda) (see Doherty, 2020). However, the invisible majority are focused on improving the business models of companies that utilize motorcycles for last-mile, express and on-demand deliveries (Cirolia *et al*., 2023).

In Nairobi, a city seeking to implement ambitious smart city plans (Guma and Monstadt, 2021) and long dubbed Africa's Silicon Savannah (Graham and Mann, 2013), a booming startup ecosystem has emerged in the last decade as a melting pot of local entrepreneurs, diaspora returnees with experience in the global tech industry, foreign companies, and international venture capital (Rosenberg and Brent, 2020). All these players have thus contributed to an explosion of platform experiments addressing not just motorcycle mobilities but many facets of the Kenyan economy, from payment technologies to agriculture (Mann and Iazzolino, 2021). While some of these platforms are international, accessing venture capital to finance the trial and interaction of their offerings, several experiments are in fact driven by home-grown, bootstrapped startups, many of which only last a few months after being launched and then wilt away or

11 Recent legislative amendments to the National Transport and Safety Authority Act seek to give the latter agency power to establish systems and procedures for the registration, licensing and operations of these categories of vehicles, just as it does with other motor vehicles. Additionally, county governments are empowered to enact regulations for *boda boda* operations within their jurisdictions. In Nairobi, *boda boda* operators will in future be registered by the county government according to the cooperative society to which they belong and their zone of operation; motorcycles will be fitted with digital plates containing information about the riders.

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pivot their business models to find more profitable last-mile market niches (Cirolia *et al*., 2023).

As we will see, the motorcycle is just one, albeit crucial, component of the platform arrangements through which last-mile startups 'see' the city. It is a vehicle (in all senses) for us to chart the practices of algorithmic suturing that seek to fill the gaps of a fragmented city, both spatially and economically.

A note on method

Our approach in this article is usefully summarized by the metaphor of 'seeing like a last-mile business model', which explicitly borrows from Scott's critique of 'authoritarian high modernism' (1998). The original phrase, 'seeing like a state', described the multiple acts of 'bringing into view' which administrative designs need in order to simplify, and therefore govern, complexity. While Scott's insights have been variously challenged—both in their empirical validity and their applicability to corporate capitalism (e.g. in Ferguson's *Seeing Like an Oil Company* [2005])—the notion that the making legible of things (for example, through measurement protocols, cadastral maps and census taxonomies) is a crucial register of power has generated a wealth of contributions in various disciplines—from Dourish's *Seeing Like an Interface* (2007) to Seaver's *Seeing Like an Infrastructure* (2021), to name just two.

In a more science and technology studies (STS)-inspired interpretation of 'seeing like' as a performative act, whereby legibility works both on what sees *and* on what is seen, John Law (2009) instead argues that realities are enacted through the methods that are purportedly meant to simply bring them into view. This insight lies at the centre of our methodological approach to understanding how last-mile 'views' render network fragmentation legible as a problem of platform coordination, whilst enabling us as researchers to follow additional leads. We would also argue that this intuition informs much of the critical scholarship on digital platforms—showcasing how the data processes through which algorithms operate are never just descriptive, but follow multiple performative logics[12] (as described by Fourcade and Healy in *Seeing like a Market* [2017]).

We are equally inspired by a body of scholarship in media and cultural studies which has shown the importance of network imagination, arguing that networks are material and metaphorical infrastructures of sensibility that mediate and narrow our experience of the world (Terranova, 2004; Galloway and Thacker, 2013; Munster, 2013). According to Patrick Jagoda, for example, networks are realities that exist at the edge of sensibility. They are at once something that we see and a way of seeing, inextricably both material and metaphorical (Jagoda, 2016). Infrastructures, therefore, cannot be thought of separately from the ways in which they are visualized. And as we have seen in Figure 1, the last mile is a key component of network visualization, pointing to its peripheral terminals. Visualization, in this context, is not just a matter of 'pictures', but a broader process of rendering visible (Halpern, 2015).

Building on these different and at times disconnected contributions, for us 'seeing like a last-mile business model' is both a descriptive device that captures the ways in which motorcycle taxis become inscribed in the algorithmic suturing of the loose ends of urban networks, and a methodological orientation. It is a methodological orientation because seeing like a last mile means charting the business models of these platforms: the algorithmic scripts through which the ends of networks are made visible as sites of coordination and optimization. As Liliana Doganova has shown in her work (e.g. Doganova and Eyquem-Renault, 2009), business models are indeed particular kinds of market abstractions: ways of seeing that participate in the making of economic

12 See, for example, Wendy Chun's *Discriminating Data* (2021).

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realities. In other words, last-mile business models are one of the 'legibility' scripts through which fractured urban networks are coordinated into digital platforms. When algorithmically visualized, fragments and sutures become more than just metaphors of urban life; they become discrete processes of spatial and economic optimization (Pasquinelli, 2019).

Cognizant that the perspective of platform startups may be contested or reinforced by how the riders themselves 'see' the algorithmic economies in which they are imbricated, as Qadri and D'Ignazio write in *Seeing like a Driver* (2022), our practical strategy to see like a last mile involved a scoping of all Nairobi-based digital platforms that incorporate *boda boda* in their operations and a mapping of both their value chains and supply chains to understand the different roles *boda boda* play in each business model. This work included trial-and-error practices of 'playing' with the apps, trying out websites, making orders ourselves, speaking to customer services, and analysing online information available for each platform, as well as accessing private archives that document investments in digital companies. In the cases we now move on to discuss, we were also able to conduct traditional 'corporate interviews' with founders and other platform managers (Schoenberger, 1991). To do full justice to this empirical richness, the three cases below are presented as detailed vignettes that showcase how each business model sees fragmented urban economies as sites of algorithmic suturing, viewed through the eyes of those whom Jane Guyer (2016) calls 'platform attendants'—that is, the creators and managers of last-mile platforms.

Seeing like a last mile in Nairobi

Global e-hailing companies such as Uber and Bolt, Africa's largest e-commerce platform Jumia, and Delivery Hero-owned e-grocer Glovo are undoubtedly the most visible operators in Kenya's last-mile urban economies. They are not, however, the sole players. As our research shows (Sitas *et al*., 2022), not only do dozens of smaller platforms exist on the market, seeking to create alternatives to these oligopolies, but several digital startups are also active in the value chain of these bigger platform firms. Through their last-mile business models, many of these fledgling companies onboard motorcycle riders into the functioning of their algorithms, with the aim of using informal *boda boda* networks as a spatial suture that reduces logistical costs and creates additional avenues of optimization.

In this section of the article, we chart the business models of three such startups—three smaller platforms that are using *boda boda* to address a number of last-mile problems—ranging from the exploitative nature of precarious work, to the addressability of lower middle-income residents, to the reconfiguration of hub-and-spoke logistics in Kenya. The first company, Cleanify, is a gig-work platform for domestic workers. The other two companies, Shoppist and Dasher, are an e-commerce platform and a last-mile logistics provider, respectively. For each of these cases, we map how their business models frame *boda boda* as a prosthetic link to issues of algorithmic optimization, and foreground what these ways of seeing make legible about urban economies in Nairobi. We therefore ask the reader to take the perspective of these businesses and to 'see' the splintered urban realities as coordination problems that can be bridged by motorcycle taxis.

– Networks of waiting among last-mile workers

Soft-spoken and eloquent, Mike[13] is the co-founder of Cleanify, a four-year-old startup offering on-demand laundry and household cleaning services. With a degree in statistics and a passion for crunching data, Mike does not have the boisterous panache of

13 All names of people and companies in this article are pseudonyms that we used to protect the confidentiality of our interviewees.

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the prototypical startup founder; by his own admission, he had to learn how to successfully promote his company by imitating the seemingly limitless confidence of others. To do so, when he and his co-founder started the company, they joined one of the co-working spaces that Nairobi is famous for. Rubbing shoulders with other 'techies' taught them how to perform at pitching events and competitions. Four years later, and despite the COVID-19 slow-down, Cleanify is running at a profit, provides employment for more than 200 women, and recently raised capital to switch from a web- to a mobile-based application.

Cleanify's business model looks very simple on paper: it is a gig-work platform through which households can hire the services of a cleaner. By charging a fee on each transaction, Cleanify replicates the business model of large platform companies, matching freelance labour with local demand. The work of the algorithm also seems rather simple: by geolocating both homes and cleaners, the platform connects the supply and demand of household cleaning services. However, as Mike explains, things are more complicated than this, both in the demand and in the supply of these services. As most middle-class Nairobians already have regular (often live-in) domestic help, the demand for gig work comes from the lower-middle class, especially from households that cannot afford the services of a regular or live-in domestic help and which (more importantly) lack cleaning appliances such as washing machines. In response to this demand, families rely on the informal work of women sometimes referred to as *mamafua* or *mamasafi* (Kiswahili for cleaning mother/lady). *Mamafua* are known to be found in specific waiting areas, usually at the interstice between wealthier and poorer neighbourhoods. They rely on the odd jobs that neighbourhood families have for them, usually hand-washing clothes and, occasionally, heavy-duty housework.

Cleanify recruited and trained a number of these women, taught them how to use their smartphones to receive and locate a 'call', assigned each of them a unique identification (ID) code, and linked them to an algorithm through which the logistics of the last-mile problem could be optimized. It is at this point that motorcycle taxis come into play. Much like these women, *boda* riders wait in specific areas of the city. Connecting these two networks of waiting spaces, Cleanify's algorithm determines whether a job will require the support of a nearby motorcycle taxi and, because *mamafua* cannot normally afford this commuting service, adds a half-dollar fee (50 Kenyan Shillings) to the end customer's bill. In this way, the platform relies on the *boda* riders' unparalleled knowledge of the city, addressing a logistical problem inherent to freelance housework.

Yet Mike is adamant that this last-mile problem was not just a profit opportunity. He explains:

> You know, platform gig companies are very exploitative because their business model functions on very small margins. Our idea was to start from the opposite side of the business model and ask how these small margins could actually help the livelihoods of these … precarious workers while addressing a need of an under-served market.

As he further notes, it is in the marginal price difference between informal work and gig work that Cleanify's last-mile innovation lies. End customers are willing to pay slightly more than they would normally because the quality of the service is better, faster, more consistent and more reliable—not least, thanks to the *boda* riders. It is in this willingness to pay (marginally) more that Mike and his business partner saw the possibility of injecting a different kind of rationality. Contrary to platform business models that seek to drive the cost of labour down, Cleanify operates to render fluctuating informal gains and working conditions more stable. The unique ID, the iterative training (which allows for returning customers), the plug-in of motorcycle taxis, and the algorithmic distribution of calls now provide every *mamafua* with a monthly income that is above the national minimum wage.

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The last-mile algorithm, however, is not just a piece of software. It entails a careful process through which Cleanify enrols various infrastructures, including human networks that make the algorithmic suturing possible. In Mike's words:

> Each area now has a group leader, and the group leader is the one who coordinates all this. So when an SMS goes to a lady and she needs a rider, she goes to the group leader, who is usually stationed in the same waiting area that we have selected as a base, and she arranges a ride. Usually our bases are close to *boda boda* waiting areas. And the company reimburses the riders at the end of the day. It's a dynamic web network that we are trying to make work through the platform. The first step was to envision the interfaces between these smaller networks and from there imagine how some key players could function as mediators between the platform and the complex dynamics of each area.

As Cleanify grows, so does the number of networks with which it seeks to interface. Informal financial infrastructures are the latest addition. When Mike and his partner saw that *mamafua* were starting table-banking groups with their savings, they prototyped a financial scheme that allows cleaners to buy shares in a savings account owned by the company. In this way, each saving club member can borrow or withdraw what they contributed (as with a normal table-banking protocol), while also benefiting from a basic interest rate that cash-based saving does not yield. These are all very small improvements, Mike admits, but they became visible by looking at the margins of the many fractured networks and treating them as data problems of algorithmic distribution: by seeing Nairobi's urban fragments as a challenge for last-mile coordination.

What we thus begin to see, through Cleanify's last-mile business model, are the complex operations through which disjunctions in urban economies—such as domestic housework—become legible as problems that require algorithmic suturing. In these operations, *boda boda* are one of the infrastructural optimizations through which platforms seek to interface with various precarious networks in the city: from cleaning services to pillion commuting and even informal banking. Rather than simply disciplining labour, or replacing more secure forms of employment with gig work, Cleanify's algorithm is designed to optimize marginal gains at the intersection of two demographics—the lower-middle class and informal workers—that not only constitute the bulk of Nairobi's dwellers, but are both extremely sensitive to changes in the price of piece work, whether to earn a living wage or to pay for essential services. The next two case studies will speak more directly to the question of affordability for the lower-middle class, and also to the unique last-mile problems that arise through creating e-commerce solutions for a shifting and elusive demographic group (Darbon, 2019) that defies sociological definitions but very clearly shapes how digital platform startups visualize their markets.

Before moving on to the next company, it is worth noting one last important thing about Cleanify. Like any startup, Mike and his co-founder have ambitious plans for the future of the business. These plans include a distributed network of Cleanify-owned ghost laundromats which will increase the number of heavy-duty cleaning options available to its customers. It goes without saying that *boda boda* will provide the logistics between these laundromats and households. In other words, seeing through a last-mile business model also sheds light on the speculative urban networks that are not there yet, but are waiting in the wings of future algorithmic iterations.

– Last-mile addressability in e-commerce

With a decade of experience in marketing for e-commerce companies, Li landed in Nairobi from southern China early in 2019 to join the marketing department of a Chinese retailer selling fast-moving consumer goods (FMCGs). He now works as the

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head of marketing for Shoppist, one of the up-and-coming e-commerce platforms in East Africa, operating in Kenya and Uganda. For many young managers of international Chinese companies, Li explains, moving to Africa is an ambitious career move, usually a trampoline to somewhere else in the world. In his case, however, Shoppist represents a rather unique journey, because the company was actually founded in Kenya in the mid-2010s by a Chinese expatriate, a former Huawei executive.

The inspiration for Shoppist was obviously the Chinese company Alibaba and the rags-to-riches story of its founder Jack Ma, who made a fortune by creating the largest e-commerce company on the globe (by gross merchandise value). Alibaba's success, Li argues, lay in its capacity to experiment with and diversify its business models, from drop-shipping to consumer-to-consumer options. For Shoppist's founder, Alibaba and other Chinese giants like Jingdong (JD.com) had something valuable to teach Africa's fledgling e-commerce sector: reaching the customers who were usually left out from online shopping platforms was not just about marketing prowess, but also about last-mile logistics, both financially and geographically.

However, as Li explains, 'e-commerce in China is very unique.... In Kenya, we [could] not just copy Alibaba or Amazon. And so that's why it was important to have local intelligence'. Local intelligence, as he later elaborates, meant more than hiring a team of locals for the operations team. It entailed relying on their understanding of the East African market, on their knowledge of specific urban economies of logistical distribution (in this case, the *boda boda* network), as well as on an iterative, cumulative process of data-powered learning.

From the very beginning, these experimental processes translated into a series of small adaptations and tweaks to more traditional e-commerce models. The first of these changes was the integration of M-Pesa,[14] Kenya's mobile currency system. This was no small feat, even though M-Pesa has an application programming interface (API) for embedding the mobile currency as an online payment option. The reason other online retailers of foreign goods only allow purchases by credit card, Li speculates, is because of the currency risk. But with M-Pesa, Shoppist became one of the first online retailers where Kenyans could buy affordable phones made in China in the same way they used to do in a physical shop: with a one-off, fully paid, cash-like transaction.

The other change in the business model stemmed from the intuition that Shoppist did not need to function completely as either a drop-shipping company (i.e. with no warehouse) or a stockist (i.e. with large-scale warehousing facilities). Shoppist's hybrid model is based on a central warehouse located close to Nairobi's international airport (in an area that is becoming more and more densely packed with this kind of logistical facility) and pop-up warehouses in Mombasa and Kisumu that it can use during peak-order periods (such as Christmas time). A three-tiered product taxonomy thus ensues: things that are already in the warehouse (where they never stay for more than a month); things that are sold by other stockists in Kenya (and are in third-party warehouses); and things ordered directly from China (which therefore only stay briefly in the Nairobi warehouse before being dispatched).

For this carefully orchestrated supply model, Li argues, coordinating the last mile is as important as understanding the suppliers. In fact, understanding the supplier side *depends* on last-mile data and coordination. For goods to move quickly to their end customers, two motorcycle-enabled solutions are crafted to resolve two addressability issues. The first is the fact that Nairobi addresses may or may not be accurately geolocated, or even have a specific house number—*boda* riders know the city well enough to fill this gap. The second is the total lack of an address, because some Shoppist customers live in parts of the city that for one reason or another are

14 This local mobile money platform was originally developed by telecom operator Safaricom. See Guma and Mwaura (2021) for an infrastructural perspective on last-mile mobile telephony configurations in Kenya.

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unaddressable. In this case, the last-mile solution consists of little delivery hubs called Shopposts. Deliveries to these hubs are fulfilled daily by *boda* riders and they have the double function of providing a delivery address for people without one, as well as for those customers who cannot receive deliveries at home during working hours. As Li explains, Shoppist customers are mostly young people who do not belong to the upper-income brackets of Kenyan society; consequently, costlier delivery options on Amazon or other e-commerce platforms are simply prohibitive. The Shoppost option is essential for this type of customer because they are less addressable than middle-class households.

While Shoppist employs a small number of *boda* riders directly, the majority of them are subcontracted through business-to-business (B2B) last-mile logistical platforms. The reason for this choice is that specialized two-wheel delivery companies have developed more efficient distribution algorithms; as we will see in the next case study, they are better at optimizing delivery routes across urban centres, and their riders have much better performance indicators than could be achieved with in-house operations. At the same time, keeping a few riders on the payroll means that Shoppist also has a degree of flexibility and can adapt to unexpected market fluctuations, particularly in Nairobi. Such a system, Li concludes, did not happen just by chance, but evolved organically using the last mile itself as a data source, constantly monitoring and experimenting with feedback loops to improve the final leg of logistical coordination, while ensuring that small tweaks to the dispatch system would not affect the affordability of Shoppist's e-commerce offering.

These are small but crucial aspects of Shoppist's business model which speak to the ways in which platform algorithms seek to mend disjointed urban fabrics. First, Shoppist visualizes the goal of selling affordable products to its target customers (the urban lower-middle class and youths) as a problem of addressability. Second, creating an e-commerce market from scratch requires incremental and iterative data-driven experiments. This is very much in line with what has been observed about large platform companies, which experiment with the city as a testbed for new products and services (Mattern, 2016). What the example of Shoppist also shows us, however, is how these experiments are framed as potential solutions to logistical problems that are unique to a city like Nairobi and to which *boda boda* networks present a gap-filling opportunity—whether by knowing intimately the complicated urban fabric of a booming postcolonial city or by buffering against the fluctuations in demand for last-mile services. Once again, as with Cleanify, the lower-middle class represents a key driver of these new economies of algorithmic suturing. Yet as with Cleanify's business model too, we catch sight of how these new companies speculate on new urban spaces (such as ghost warehouses and distributed delivery hubs) as the future interfaces through which algorithmic economies will latch onto the city.

– A last-mile crouching tiger

To find one of the specialized last-mile companies that support e-commerce platforms like Shoppist, one doesn't need to travel very far from the headquarters of the latter. At the southern end of Mombasa road, Nairobi's main traffic artery, stands a growing cluster of depots and other logistics operations, attracted by the proximity of Kenya's main international airport, the terminus of the newly built standard-gauge railway, and access to the country's busiest highway. At the crossroads of these networked systems, Dasher occupies two large warehouses painted in bright colours, one being the distribution centre and the other a sorting facility.

Dasher is one of an increasing number of small last-mile companies that offer logistics services through a network of *boda* riders across Kenya. Unlike bigger platforms like Uber and Bolt, Dasher only operates in the B2B market, offering a plug-and-play delivery service to e-commerce businesses. This is explained to us by Jenny, a minute, animated young woman who is head of sales for the company, which was started by

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a small team of Chinese expatriates in late 2020. Kenya was not their first market, however. Dasher is the subsidiary of a conglomerate already active in half a dozen African countries, as well as, more recently, in the Middle East. These subsidiaries all report to headquarters in Shanghai but, as Jenny elaborates, they only do so once a year, and Dasher is an independent business unit operating as a startup. The investment came from one of China's leading express delivery companies, a logistics firm that made its fortune on the heels of e-commerce giants like Alibaba and JD.com and which now handles a staggering volume of more than ten million parcels a day. Its expansion into the African market replicates the model that the company used in China, with a growing cluster of subsidiary startups that gradually formed a comprehensive network of logistical services, from line-haul first-mile to express last-mile solutions.

In Kenya, Dasher is spearheaded by Kevin, a tall young man who cut his teeth as a logistics manager in southern China during the heyday of the e-commerce boom, ten years prior to relocating to Nairobi. Sitting with Jenny in a small office separated from the sorting facility by a glazed wall he maps out Dasher's network for us. At the centre of the network stands the warehouse complex in which they welcomed us. Parcels coming in from overseas, for example, are scanned in the sorting facility. This is a manual operation but it is augmented by technological equipment imported from China and by in-house software that Dasher built itself to automate its logistics management. In the future, Kevin plans to import a fully automated sorting belt, but so far the volume of parcels does not warrant a large-scale machine. From the sorting facility, items move across to the distribution centre. Here, parcels are assigned to variously sized trucks and vans which head out to smaller distribution hubs across the city and in most of Kenya's other counties.[15] These are either small shop fronts with a loading bay or, in some cases, other businesses acting as franchisees. From these hubs, *boda* riders bridge the last-mile gap, delivering parcels to end customers on behalf of Dasher's B2B clients. These hubs are also drop-off points for domestic deliveries: once an item is scanned in at one of these hubs, it travels to the main distribution centre in Nairobi from where it is line-hauled to the destination hub and eventually delivered by local *boda* riders. This centralized system responds to the need to optimize the interface between the middle and the last mile, Jenny explains, pointing to the second warehouse building:

> Everything goes through this DC [distribution centre]. So, for example, between Meru and Mombasa trucks would be half full. But because they all go through this DC, we make sure that all the routes are optimized … In logistics, the most important thing is the network; the more a network is capillary, the bigger your abilities.

The ultimate capillaries of this network are indeed the *boda* riders, she goes on to explain, showing us the algorithmic system that renders each rider and each parcel a discrete data point thanks to the barcodes that are scanned at key points of a delivery.

Unlike other large on-demand labour platforms offering parcel services, Uber included, Dasher does not rely on a casual workforce. The riders are all formally employed, although their wages are piece-based. Only during peak periods such as Black Friday are temporary riders added to the base team, which, after just one year of operation, already comprises some 200 members (ranging from 75 in Nairobi itself to just a couple in smaller cities). While casual labour would be a cheaper option, Dasher decided to invest in training couriers so as to baseline their customer service quality and make sure their riders are indeed data collectors as well as couriers. Although neither Jenny nor Kevin mention it explicitly, and only refer to a 'politeness' problem, it is

15 Since the constitutional reform of 2010, Kenya has been divided into 47 counties which vary greatly in both size and population.

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clear that the decision to onboard riders as employees is a way to address the negative perceptions which surround the *boda boda* sector in Kenya.

In many respects, Dasher is not unique in its business model or in the way that it formalizes *boda* riders as direct employees. Research into platforms has shown time and again that on-demand work can make labour less rather than more precarious, but not necessarily different or better (Schor *et al*., 2020). Nonetheless, by examining the ways in which Dasher visualizes its last-mile network we catch a glimpse of how business models envision the future of urban mobility infrastructures. Both Kevin and Jenny explain that Dasher's aim is to become Africa's 'number one last-mile service provider' dedicated to e-commerce. This is something of a pipedream, as they admit, since e-commerce in Africa is still only a very small market. But they are playing the 'long game', says Kevin, arguing that it only takes two ingredients for e-commerce to boom: a functional, diffused online payment system and effective last-mile logistics:

> If anyone can solve these two things, online payment systems and last-mile logistics, e-commerce will be pumping … No country can escape e-commerce. I don't know who will be the last winner. In America it's Amazon, in China it's Alibaba, and in different countries they have their own. I don't know who will be the winner in Africa. But whoever it is, they'll need us.
>
> So why did we come here? At this phase, we are building the night work. We've connected every county, trained our team, taught them how to be ready. We are waiting like a crouching tiger.

In playing this long game[16] while African e-commerce develops, Kevin is already working on the distributed infrastructure that a boom in the demand for last-mile delivery will mean for a city like Nairobi. He has ordered twenty smart cabinets from China. These cabinets, which will be distributed across the city to shopping malls and large corporate offices, will function as the last-mile endpoints to Dasher's delivery services. Enabled with Internet-of-Things (IOT) technology and fully automated, the cabinets sport the same bright colours as the company's brand and are equipped with small lock-boxes. Every day, *boda* riders will fill and take from these cabinets across the city—addressing the same issue of addressability that Shoppist is trying to solve with its Shoppost model.

The prototype of one of these smart cabinets, soon to become a fixture of urban life in Nairobi, sits just outside the office where Jenny and Kevin are talking to us. In many respects, Dasher makes some of the same issues that we have already seen in the two previous case studies legible; once again, as problems of last-mile algorithm coordination. Motorcycles, in Dasher's business model, contribute to a unique hub-and-spoke logistics model in which the gap-filling capacities of the *boda boda* sector are visualized as both capillaries of a larger distribution network and the data-gathering terminals of this network. In other words, algorithmic suturing is always more than just software-based 'tricks' (Pasquinelli, 2019: 6): it entails riders, motorcycles, cabinets, warehouses, and so much besides. What is also worth noting—which Dasher illustrates even more than the other two cases—is the speculative nature of these platforms; not only does Dasher currently operate at a loss, waiting for an e-commerce boom that may or may not materialize, but it does so by speculating on a spatial network of distribution that is currently in the making but not there yet. As we move now to the conclusion

16 In a way, this confirms and extends C.K. Lee's (2017) argument that corporate China in Africa is often involved in practices of profit optimization rather than profit maximization. While Lee's point is specifically about state capital as opposed to other varieties of capital, our research suggests that Chinese tech startups in Kenya also operate across diverse temporalities of profitability.

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of this article, we will return to the importance of these future-making algorithmic practices for urban research.

Conclusion

What can be seen about a city when one starts with the business models of last-mile startups? How do *they* see, make sense of and make visible the ends of splintered urban infrastructures and economies? Of course, these are complex questions that can be cut and sliced in many ways (Qadri and D'Ignazio, 2022). Owing to the ubiquity of the motorcycle in the provision of last-mile logistics in African cities, we have intentionally selected startups that tap into Nairobi's (in)famous *boda boda* sector as our entry point into this way of seeing and making legible. *Boda boda*, as we have shown, operate as a prosthetic tie that helps suture the fragmented urban infrastructures of Nairobi. Increasingly, they do so through digital platforms, and through processes that we have labelled using the concept of 'algorithmic suturing': the more-than-spatial patching of urban fragments through practices of data-driven optimization.

Our contribution with this article is therefore both empirical and conceptual. On an immediate level, our case studies show how last-mile algorithmic business models seek to stitch together splintered infrastructures by making them legible as sites of coordination. More specifically, what last-mile business models visualize—and therefore seek to address—are the gaps in the urban economies that they can tap into. In this sense, our research speaks to a body of Southern infrastructure and Southern urbanism scholarship which has shown how in Southern cities networked systems (where they exist) are gap-filled and sutured by practices of material improvisation and the marginal technological survival of the poor. Yet the last-mile examples we have narrated in this article point to something different: stitching together the loose ends of splintered urban infrastructure is about *more than* material improvisation, or individual responses, or marginal practices of survivability. Algorithmic suturing is, in fact, a deliberate, elaborate set of experimental business models through which urban fractures become legible as problems of optimization and, therefore, as sources of value. In other words, acts of suturing are not just performed by informal economies through make-do thrift, but by deliberate algorithms that seek to integrate the latter into (perhaps) profitable data-driven platforms.

Moreover, while there is a tendency (particularly among scholars who have sought to reconcile top-down readings of infrastructure and platforms with everyday lived experiences) to assume that suturing happens at the individual level, or at small collective scales, the last mile is about big numbers: it is about producing algorithmic stitches that do not address single splinters of urbanity but enrol whole interfaces between inconsistent economies, using the ends of these networks—the last mile—as a constant data source to recursively coordinate better and optimize more. Put differently, the 'infrastructural heterogeneity' often attributed to Southern cities (Lawhon *et al*., 2018) is also the calculated outcome of highly scalable business models. Uber and the like know this very well, and to leave this insight with them represents a missed opportunity for urban research on digital infrastructure, both in the African city and beyond.

Seeing like a last mile is also a methodological intervention. Like any method, as John Law reminds us (2004), our approach makes some things legible while others fall into the background. We have mentioned, for example, how the exploitation of platform labour (Van Doorn, 2017) is not the focus of this article. At the same time, our perspective inductively calls attention to important undercurrents sweeping across African cities. The cases we have outlined hint at some of these issues, which we cannot address in full here. However, it is worth highlighting a few of the issues which merit a much richer urban inquiry. The last mile sees, for instance, the possibilities that lie within the needs and aspirations of the lower rungs of Africa's urban middle class, as well as the

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inescapably tight margins of this demographic as drivers of urban change. The last mile also reveals the impressive strides made by Chinese tech and e-commerce companies, so often overlooked by scholars concerned with China's large-scale and state-driven investments (Pollio, 2022b). Finally, these business models also foreground the quiet emergence of new spaces of urban logistics such as dark kitchens, dark laundromats and ghost warehouses (Shapiro, 2022), or even more mundane urban 'objects' like smart cabinets. Last-mile startups envision and speculate on these spaces and objects before they are materialized, when they are still being considered, planned and tested. Algorithmic suturing, we have shown, is speculatively experimental.

On a more pragmatic level, the last mile sheds light on the diverse forms of value promised by these platformed urban economies and the various shades of invisible work and knowledge that sustain them (Irani, 2015). There is a need, we believe, to bring the perspective represented in this article into scholarly research that centres questions of labour, recognizing that labour dynamics are also and fundamentally shaped by contextual practices of algorithmic suturing. Without a fuller appreciation of this nexus, we are already witnessing the emergence of regulations (and the purposeful lack thereof) which negatively affect those whom they are meant to protect. As engaged researchers, we will seek to make these insights speak to regulators and industrial players through the work that we do beyond academic publishing. In the meantime, our hope is that scholars of cities and infrastructure will take up the research challenges that the last mile makes visible, some of which we have outlined in this article.

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