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The rise of urban tech: how innovations for cities come from cities

Patrick Adler[a] and Richard Florida[b]

ABSTRACT

This research investigates the economic geography of urban technology, or 'urban tech', start-up enterprises. Comprised of ride-hailing, co-living, co-working, smart cities and other urban-oriented activities, urban tech is a suite of innovations that enable and are premised upon growing urbanization. We investigate where urban tech comes from by analysing Pitchbook, a database of venture capital deals, to chart the evolution and geography of urban tech start-up firms. We show urban tech firms to be highly clustered in two kinds of places: specialized tech hubs such as the San Francisco Bay Area and large cities such as New York, London and Beijing. Furthermore, we find that urban tech geography is associated with two classes of factors: the scale of existing tech activity, and the size and extent of metro areas. Together these findings suggest that the geography of urban tech is shaped by the innovative capabilities of urban areas and, to a lesser extent, by urbanization itself. Urban tech investment is less common in areas associated with 'Industry 4.0' industrial policy.

KEYWORDS
urban technology; urban tech; urban innovation; clustering; talent; Industry 4.0

JEL B50, O
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INTRODUCTION

Cities have been intertwined with technological innovation since the dawn of human civilization. Ancient cities were the centres for advances such as cave paintings, rudimentary written language, toolmaking, and the first urban walls which were erected in Mesopotamia *c.*3000 BCE. Today, cities and innovation are more inextricably connected than ever. A substantial literature already documents the role played by density, cities and urbanization in the process of innovation. But now increasingly cities are not only the platforms for innovation but also the subject of a new wave of technological change.

Our research examines the rise of a new set of technologies and start-up enterprises that are the fundamental products of cities. This new suite of technologies, which we refer to as urban tech, are premised on solving urban problems and making cities function more efficiently. They include innovations such as ride-sharing, home sharing, smart cities, urban delivery and more.

The urban impact of these technological changes is the subject of a growing body of research (Cooke, 2021; Cowley et al., 2018; Kitchin, 2014; Meijer & Bolívar, 2016; Shearmur, 2016). To date, there has been significant progress in understanding how these technologies are altering urban behaviour as well as the implications of these technologies for urban law and planning. These discussions tend to focus on the 'demand side' of urban technology markets focusing on questions such as how do these technologies change society and how should society respond? We focus here on the supply side of urban technology – emphasizing the factors that underpin and shape the spatial organization of urban tech production. Our research thus seeks to understand where commercialized urban innovations are coming from. We ask where urban tech enterprise and clusters are based. We are specifically interested in whether this geography resembles the highly urbanized and clustered spatial pattern of other leading high-tech sectors.

To get at this, our research uses detailed micro-data from Pitchbook, a database of venture capital deals. We use these data to chart the evolution and geography of urban tech start-up firms and to inform models that examine the key factors underpinning that geography. We look at two classes of factors specifically: the first focusing on

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the scale of high-tech start-up clusters, and the second on the size and scale of metro areas.

We find that urban tech deals and investment flows can be mostly explained by venture activity in other sectors. But the geography of commercialized innovation has itself recently been changing, as noted elsewhere (Florida & Hathaway, 2017). Thus, urban tech enterprises are not just concentrated in iconic tech centres such as Silicon Valley or Boston but also in large global cities and metropolitan areas such as New York, London, Beijing and Paris, which provide the platforms not just to generate these technologies but to adopt and apply them. The key factors in this geography of urban tech seem to be population, economic size, and access to universities and pools of talent.

The rest of this paper proceeds in four parts. The first reviews key concepts and theory advanced by prior literature, establishing our framework for exploring the rise and geography of urban tech. The second covers our research methods, data and analysis, providing our definition of urban tech, discussing the Pitchbook data, and our research methods and models. The third section reports our findings, highlighting the role of cities in not just generating but adopting this new suite of urban technologies, and documenting the factors which underpin the geography of urban tech. In the fourth section we reflect on our findings in light of broader conversations about urban-oriented knowledge-based or digitally mediated capitalism, showing how the geography of urban tech is closely connected to wider geographies of innovation and how large urban agglomerations are favoured by urban technology diffusion.

CONCEPTS AND THEORY

Cities are being remade as technologies such as ride-sharing, autonomous vehicles and smart infrastructure are implemented. A growing body of research focusses on the rise of smart cities and associated urban innovations. Despite this, the economic geography of the urban tech sector remains insufficiently understood.

Conversations about smart city technology date back at least to the early 1990s (Gibson et al., 1992) before the mass adoption of personal computing. As digital technologies became more widespread, 'the smart city' came to be a catchall term for all urban applications of information and communication technology (ICT) technologies. The number of smart city citations was estimated to have increased by a factor of 600 between then and 2014 (D'Auria et al., 2014). A meta-analysis of this scholarship (Mora et al., 2017) reveals this literature as somewhat chaotic with researchers pursuing personal trajectories more than scientific exchange over a common set of ideas. Moreover, there appears to be a major divide between those who view smart cities as wholly technical artefacts and those who understand them as new configurations in how humans and technology interact. The latter view is encapsulated by Caragliu et al. (2011) who depict the smart city as the environment where human capability, social capital and informational technology meet. The former is captured by the likes of technology firms and consulting companies which uncritically herald the commercial potential of internet-connected infrastructures.

In the past decade or so, the human–urban relationship has become fully mediated by computer technology and some of the most significant technologies (e.g., automated vehicles) are still imminent. The mobile web represents one of the most significant urban tech achievements to date. Wireless connectivity in smart phones and laptops has relieved urban dwellers of the choice between movement and connectivity. The urbanite of 2007 had to stay still to access the internet, either at their private computer connection or at a public portal such as a computer lab or internet café. Today, mobile connections are almost essential for navigating the city and monitoring local conditions. Modern digital services have also improved how markets for urban space, labour and social connections operate. Digital platforms allow users to access information about nearby opportunities and in real time. When there is a density of such opportunities in urban environments such technologies can speed up and rationalize interactions.

Research into urban technology has also matured in the past decade or so. The widespread adoption of some technologies means that scholars can empirically investigate the sector as it is rather than as it is projected or feared to be in the future. Mobility and space-sharing applications have gained the most purchase in cities as well as the most attention by scholars and policymakers. Urban tech innovations have been disruptive to existing cities and their economic systems, particularly urban labour markets. Taxi services have not been completely replaced by ride-hailing, and hotels have not been fully switched out for Airbnb units, but these older industries and many more have contracted under pressure from urban tech. Nowhere is the impact of technology on cities more visible than in the disused retail districts and strip malls that have fallen victim to platform-based e-commerce. The Covid-19 period has seen a transition to work from home (Bick et al., 2020) arrangements in sectors with sufficient technological capacity to support it. Many of the systems supporting virtual work and social distancing (food delivery, contract tracing software) did not exist a decade ago.

Mobility applications such as Uber and Didi Chuxing connect those who want to move around the urban environment with a means of doing so. This may mean linking drivers and riders, but it can also include making mobility infrastructure such as cars, bikes and scooters available or improving wayfinding. Each of these applications relies on mobile computing hardware backed by location-tracking software. These ride-hailing technologies have significantly impacted cities. A 2017 study found that nearly one in three residents of major American cities used ride-hailing applications such as Uber (Clewlow & Mishra, 2017). Ride-hailing services appear to substitute for taxi trips, and to a lesser extent for public transit.

However, they also appear to expand access to transportation: increasing the total number of trips taken and leading to less excess capacity than taxis (Cramer & Krueger, 2016). The balance of substitution and complementary effects is somewhat ambiguous as is the net impact of these services on congestion (Jin et al., 2018). However, all these results imply that mobility apps improve the economic functioning of cities, either because they allow more trips or cheaper trips or (most likely) both. Ride-sharing access has also been implicated in wider social change, such as a decrease in drunk driving and an increase in risky alcohol consumption (Burgdorf et al., 2019; Dills & Mulholland, 2018).

Airbnb and OYO Rooms are space-sharing services that are like ride-sharing applications for venues. Buyers and sellers are connected directly and securely via software which supports transactions by providing information about price and quality. Through this arrangement, smaller increments of space can be rented for less time.

In theory, co-living and co-working technologies allow for underused urban spaces (spare rooms, seasonal flats, meeting rooms) to find markets, expanding the functional supply of urban space. However, such services also allow for whole parcels of real estate to be taken from the less lucrative long-term housing market and directed toward short-term rentals. Early indications are that Airbnb has led to higher rents for long-term residents and lower costs for visitors (Barron et al., 2018; Farronato & Fradkin, 2018; Horn & Merante, 2017; Zervas et al., 2015). As with ride-sharing, the uptake of these services suggests that they are productivity-enhancing in the aggregate, if not welfare and equity-improving. What is self-evident is that technologies that make it easier to match people with otherwise unused urban space (restaurant tables, board rooms) are both efficiency and welfare-enhancing.

Airbnb, Uber and other urban-inflected services are often referred to as urban platforms, the platform being the software that allows for neighbours to interact and acquire verified information about each other (see Artioli, 2018, for a review). Discussions of these tend to be more concerned with how they should be governed (Ferreri & Sanyal, 2018; Kenney & Zysman, 2016). Urban applications, like other software platforms, are subject to network externalities: they become more useful to their customers as the producer network grows. The more drivers or letters on a platform, the better the selection and the stronger the competition; but larger networks also mean monopolistic market structures at the platform level.

There is also significant concern about what these newer, urban technologies imply for the balance of power between citizens, workers and society. There is extensive discussion in urban planning and geography about how to respond to the proliferation of urban technologies. This literature tends to foreground political processes, especially how urban technologists and residents contest urban public goods (Cowley et al., 2018; Kitchin, 2014; Meijer & Bolívar, 2015; Shearmur, 2016), and is concerned with identifying alternatives to current governance models (Greenfield, 2013; Krivý, 2018).

Our approach to urban tech uses the classic lens of industrial geography. We know that urban technologies do not come from nowhere but exactly where they hail from and why is a non-trivial aspect of their emergence. Who produces urban tech not only affects who profits from it, but also whose idea of an urban technology fix will hold sway over cities the world over. The poverty of knowledge on this topic is surprising, considering that urban technologies fit squarely under the rubric of Industry 4.0, a common shorthand for modern industrial capitalism that emphasizes the role of digitization, automation and miniaturization in reshaping industrial organization (Bellandi, 2019; Lasi et al., 2014). Here, we seek to contribute to an understanding of the geography of urban tech by conceptualizing this sector, mapping and analysing its geography, and discussing it in the context of current discussions about regional polarization.

By focusing on the supply side of urban tech, our study seeks to broaden the potential geographical scope of urban tech research to include lagging industrial regions. Urban technologies need not be produced in start-up hubs where previous generations of high-tech innovations were generated. They comprise a subset of a much broader range of Industry 4.0 technologies which span sectors such as information technology, robotic automation and cyber-physical systems, which can theoretically be produced in older industrial cities or other regional production systems (Bellandi et al., 2020). Detroit, Stuttgart or Nagoya, for example, would seem to have automotive capabilities that can be leveraged in ride-sharing services and/or automated vehicle production. Indeed, production engineering for highly automated trains deployed in cities such as Beijing, Helsinki and Singapore come from Saguenay, Canada, a small region of fewer than 300,000 people. To what extent do smaller or older industrial regions play a role in the geography of urban tech?

Our research seeks to deepen the understanding of the geography of urban tech by conceptualizing this sector; mapping and analysing its geography; probing its geographical determinants; and contextualizing its role in modern economic activity, society and public policy.

Urbanism and technology

Our research is defined by the broader relationship between urbanism and technology. In the most basic sense, cities are areas where human activities are organized at high density. They reflect a desire for spatial concentration, whether for the purposes of production, exchange or interaction. Economists refer to the unique advantages of such social proximity as agglomeration economies (e.g., Duranton & Puga, 2004).

The collision of people in cities is not without unique problems, especially those related to congestion. Roads tend to be more clogged, air more polluted and housing more expensive in bigger cities because these goods are somewhat inelastic in supply and their quality depreciates when supply cannot keep up with demand. These congestion costs act as theoretical limits to agglomeration.

Beyond some threshold, the benefits from density would be overwhelmed by its costs.

Infrastructure is itself an agglomeration economy, or more specifically an urbanization economy. The scale of density that is permissible at a given time is mostly determined by the technological sophistication of urban infrastructure, that is, the degree to which the material form of cities counteracts congestion. As urban infrastructure becomes more sophisticated, cities are allowed to become denser. Contemporaneous accounts described industrial Manchester, London and Chicago as barely inhabitable due to their immense crowding (Morris, 1902; Sinclair, 2003). Today, those cities provide cleaner water and air to considerably more people; and even the new industrial cities of Asia and Africa are more inhabitable than their ancestors because of newer and better infrastructures. Urban technology thus increases the efficient city size (Henderson, 1974). In urban scaling terms, they are they periodic innovations the permit urban scaling to continue at a somewhat steady rate (Bettencourt et al., 2010).

Accordingly, we define the urban technology sector as consisting of technologies that permit greater levels of urbanization. This approach allows us to avoid the potentially ambiguous features of concepts such as smart cities, which tend to conflate function such as information intensity and form such as actuators and sensors, and to relate the concept of urban technology to long-term urban evolution.

Defining urban tech

Urban technologies are those that enable higher steady states of agglomeration. We conceive of the urban tech sector as and industry or 'organized field' (à la Powell, 1990) of firms, workers and institutions devoted to urban technologies. Ultimately, industry categories are heuristics that enable us to count similar economic activities and compare them with others. They are not, as is sometimes assumed, platonic classes that partition the economy in its true form. The same firm might conceivably belong to several industry designations at the same time and despite the best efforts of capable researchers, some activities defy categorization. It is with these disclaimers in mind that we define and describe the urban technology sector. What unites ride-sharing, co-working and co-living, smart cities, and more is that they are all directed towards problems that stem from an agglomeration/congestion trade-off.

To identify the constituent categories of urban tech, we surveyed 17 key informants including technologists, academics and policymakers. Working in consultation with these experts, we established eight subcategories or verticals, which we summarize as follows:

- *Mobility applications*: digital platforms that permit more and faster movement through cities directly respond to the agglomeration/congestion trade-off. Ride-hailing applications, discussed above, do this not only by connecting riders with drivers but also with the means to navigate the city themselves (bikes, scooters, maps, transit access). Waze, the Israeli-founded Alphabet subsidiary, is a software that allows for drivers to adjust to real-time traffic conditions and avoid more congested areas. Effectively, mobility applications connect drivers with lesser used road infrastructure.
- *Shared spaces*: applications that rationalize excess urban space include Airbnb-type services and services such as Open Table, which allow diners to reserve restaurant space. Critical observers lament that rental housing problems are exacerbated by such services, but from the standpoint of urban agglomeration the transition from long-term to short-term types of housing represents and upscaling of urban activity – that is, more filled beds per square mile.
- *On-demand delivery services*: on-demand delivery services such as Instacart, Uber Eats or Door Dash allow for consumers and firms to be connected to goods without moving. These services make urban congestion more tolerable, even as it increases. Food delivery services are an obvious example. Instead of braving the commute to a restaurant, the urban consumer can pay someone to absorb gridlock-related stresses on their behalf. Relatedly, services such as Task Rabbit allow for users to get access to on-demand labour, relieving them of the need to travel to their vendors.
- *Smart infrastructure*: information upgrades to the physical infrastructure of cities should be considered urban tech. These technologies allow urban infrastructures to collect and respond to information about how they are used. Ratti (2010) dubs this set of technologies the Senseable City. They are hardware-based solutions to be contrasted with the platform-based solutions reviewed above. They include applications such as smart water and energy meters that allow users to monitor and adjust consumption. Also included are parking systems, which allow for parking spaces to be priced and therefore rationed (Mathur et al., 2011; Shoup, 2017). In general, the application of digital sensors to urban infrastructure allows for better pricing of the same, reducing public goods problems. Compared with the platform-based services discussed above, smart infrastructure tends to consist of heavy physical systems, the sort of products that demand large manufacturing plants. Such activities resemble traditional manufacturing more than app development.
- *Real estate technology or prop tech*: firms that are developing new organizational forms for the real estate industry should be considered urban tech. WeWork is a network of urban co-working spaces that frees its users from the demands of long-term leases for fixed amounts of space and allows for users to access space on demand at a global network of offices. Its recent financial difficulties notwithstanding, the company has developed more flexible and scalable real estate products that have been embraced in the largest cities. Efforts to cheapen housing construction technology or to expand the supply of housing through microunits are similar.
- *Automated service work*: the high cost of living in large, expensive cities threatens the ability of these economic

systems to retain lower wage service workers (Florida, 2017). Service work is said to suffer from a cost disease whereby the marginal productivity of labour does not improve, and a higher and higher share of household income goes to this work over time (Baumol, 2012). Automated service work, particularly automated retail, represents a way past this impasse. Amazon's cashierless stores that leverage geo-tracking and mobile payment technologies permit frontline work to be fully automated. Elsewhere, applications of technology on the frontlines of hospitals, and automated surveillance systems work in the same way to substitute labour for functions such as greeting and checking in.

- *Vertical farming/urban agriculture*: the development of vertical farming technologies (Pitchbook, 2018) is also an example of an agglomeration-enabling innovation. As the extensive borders of cities expand, urban uses tend to displace traditional arable farmland for simple economic reasons (Seto & Ramankutty, 2016). In this context, cities demand a more intensive/vertical use of farming (Benke & Tomkins, 2017) to maintain food sovereignty (Morgan et al., 2014).
- *Urban engagement technologies*: In the same way that buyers and sellers can connect with each other on urban platforms for verified, location-based transactions, urban platforms are conduits for non-market interactions. A service such as Next Door, a social network exclusive to neighbours in the same postal code, is urban tech. Similar applications allow for political mobilization, and even provide a mechanism for opposition to urban tech to be organized. Unsupervised matchmaking services have become crucial to modern dating markets. In each case, there are non-linearities in the efficacy of the platform with respect to urban size.

Urban tech's role in Industry 4.0

The urban technologies described above can also be placed in the category of Industry 4.0, a term reserved for 'digitally augmented productive processes and product service systems' (Bellandi et al., 2020, p. 2). Even urban agricultural infrastructures such as vertical granaries are heavily dependent on sensors to monitor agricultural conditions (Sensoterra, n.d.). The deployment of some of these technologies via large, networked platforms and their various business to consumer instantiations should not disqualify them from discussions of these as part of Industry 4.0. Fassio and Nathan (2020) show that the geography of Industry 4.0 production is decidedly more urban in the Swedish context.

This strand of literature helps to inform our research into the geography of urban tech. We can conceive of three types of places or spatial 'niches' (Popielarz & Neal, 2007) where urban tech activities are likely to concentrate: leading tech hubs, large global cities and traditional industrial regions. Leading tech hubs such as San Francisco and Boston benefit from incumbent advantages for all technology formation in the form of non-venture technology companies and venture capital networks. Large, globally connected cities would have several advantages as sites of urban technology formation. They would have higher human capital levels, which have been associated with entrepreneurial innovation (Adler et al., 2019; Kerr, 2010). These would reflect more diverse economic structures which have themselves been linked to innovation (Duranton & Puga, 2004; Jacobs, 1969). Large cities might also be attractive because they offer the best seedbeds for urban technologies – working laboratories for new products and services. The premise that urban tech lays down its production roots in industrial areas is also credible. Much of the urban tech economy, especially Smart Cities' innovation, is tied to the production of heavy physical outputs of the sort that are made in traditional manufacturing systems. Industry 4.0 is also a sector where localization benefits might prevail (Bellandi et al., 2020; De Propris & Bailey, 2020). Territorial servitization, the phenomenon where an existing industrial system combines its local division of labour with information technology to generate new products is one possible advantage. There is a strong sense that industrial policy can support Industry 4.0 activities in industrial areas precisely because they are fertile environments for manufacturing.

Identifying urban tech

We use detailed micro-data on venture capital activity to define urban technology firms and the urban tech sector. Here we follow previous research on the geography of innovation. Researchers working on the geography of innovation have a limited number of options for operationalizing innovative activity, none of which will completely capture the underlying construct. Some track patent citations (Jaffe et al., 1993; Kerr, 2010) or star scientists (Zucker & Darby, 2007), but these strategies focus more on the generation of knowledge than on commercially viable ideas. Others use product innovations (Feldman & Audretsch, 1999; Feldman & Florida, 1994). We follow studies such as (Chen et al., 2010; Florida & Kenney, 1988; Samila & Sorenson, 2010), and use venture capital activity as a proxy for market-oriented innovation.

Venture capital has become the dominant means of connecting young firms to the resources necessary to expand production capacity and scale up demand. Almost all the major urban tech firms that have been named thus far, and most notably Uber and Airbnb were incubated in the venture capital system. The venture system (Bertoni et al., 2019) has also recently become a conduit for state investment in innovation. Venture capital is an eminently observable dimension of urban tech. Investors themselves are the primary consumers of data on venture investment and they demand statistics on a continuous basis. They also want data that is comparable across nations and regions. Data providers such as Pitchbook deliver this real time intelligence with much more frequency than government data collection agencies. An additional advantage of the Pitchbook data is that it is global – allowing for researchers to conduct a full accounting of how investment is distributed at a given time.

Figure 1 depicts our strategy for using Pitchbook to identify urban tech start-ups. We first identified industry

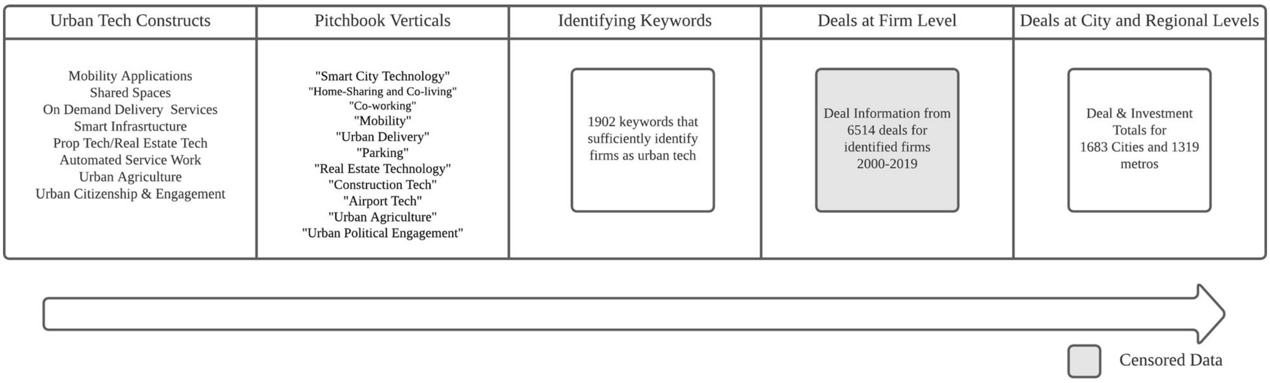

Figure 1. Estimation strategy for counting urban tech at a regional level.

categories or verticals – coded by Pitchbook that corresponded with the conceptual constructs above. There were several more verticals than constructs. This established a preliminary but insufficient list of urban tech venture deals since Pitchbook definitional criteria differs from our own. To refine the list, we identified all keywords that Pitchbook used to code firms in the preliminary list. Using the keyword list as a sampling frame, we then identified all keywords that sufficiently identified a venture deal as urban tech (i.e., all words indicating that the funded firm's technology contributes to higher levels of urbanization). As an example, 'mobile application' is not an identifying keyword because it does not designate an urban use but 'ride-sharing mobile app' and 'bike-sharing platform' are because they refer to services that require minimal urban scales to function.

We ultimately identified 1902 identifying keywords. Space does not permit us to list them, but they can be found at http://placewonk.com/urbantech. To identify a final list of firms, we retrieved all firms on the Pitchbook database coded with at least one of those keywords. Due to our data-sharing agreement with Pitchbook, data were disclosed to us at the city level, and not the firm level. We converted city-level data to regional categories at the NUTS-3 (Europe), combined statistical area (CSA) (United States) equivalent, producing 1319 metros that hosted urban tech firms between 2000 and 2019.

Figure 2 lists the key variables in our analysis, describing them and our sources. We use two measures of venture capital activity. Our primary measure is venture capital deals, which is essentially a count of venture capital investments in firms across various geographies. Deal flow, as captured by the number of discrete financing transactions, is a more reliable metric than revenue because it is more complete and less sensitive to so-called 'mega-deals'. A study of the geography of global venture capital activity writ large (Florida & Hathaway, 2017) focuses on deal flow for similar reasons. We also use a measure of venture capital investment which captures the total money value attached to deals. Our data track venture capital activity for the 2010–19 period.

Regression models

We employ a series of regression models to further probe the geographical determinants of urban tech. Our models apply to top global cities, and include variables for overall

	Variable	Description	Source	Year
Depednent Variables	Deal Count	Number of venture capital deals funding firms in a region	Pitchbook	2000-2019
	Mega Deal Count	Number of $25 Million+ venture capital deals funding firms in a region	Pitchbook	2000-2019
	Venture Capital Investment	Total known investment for firms in a region	Pitchbook	2000-2019
Independent Variables	Top Universities	Region is reputed to have a Top 500 global university	Times World University Rankings	2018
	Mega Region	Region is part of a nightime light-detected extended urban region	Adler et al. 2020	2019
	Metro Population	Region population at the NUTS-3 / CSA equivalent	Brookings Global Metro Monitor	2018
	Metro GDP	Regional economic output in Nominal GDP at the NUTS-3 / CSA equivalent	Brookings Global Metro Monitor	2018

Figure 2. List of key variables.

venture capital investment (from Pitchbook); the presence of leading universities based on the Times World University Rankings (2018); size and scale of metro areas and mega-regions (as described in Adler et al., 2020) based on population and economic output (via the Brookings Metro Monitor; Bouchet et al., 2018).

FINDINGS

Having now discussed concepts, data and methods, we now turn to the key findings of our analysis. We start with descriptive statistics and then turn to the results of the models we use to deepen our analysis of the factors associated with the geography of urban tech.

Global trends in urban tech investment

Urban tech investment accelerated in the 2010s (Figure 3). The industry raised an ample US$20 billion in 2015 and a still larger US$70 billion in 2018 before trending slightly downward in 2019, as some well-known companies such as Uber and WeWork struggle to meet expectations. Even in the last year of the decade, roughly one out of every five venture deals were in the sector.

Figure 4 maps the share of urban tech deals for each country in the first and last two years of the 2010s. We see that the concentration of deals in the United States has increased from 42% to just over half. However, we also see that India, China and Russia – three countries that have not traditionally had strong venture financing systems – are also represented. This is consistent with Florida and Hathaway (2017) who point to a 'rise of the rest' in the venture financing sphere, generally.

UK firms have the most urban tech deals on a per capita basis with an average of three deals per million people per year between 2018 and 2019. They are followed by the United States (2.4), Israel (2.1), Singapore and Finland (1.9), and Sweden, Ireland and Canada (1.8). The clearest trend in these maps is the ubiquity of white space. The median country in the world – while being mostly urban – does not have strong venture financing in this area. Urban technology firms have emerged in groups of countries with established innovative pedigrees. The top 20 nations for urban tech deals almost exactly match the G20. The only non-G20 nations included are Israel and Singapore; the only G20 nations excluded are Indonesia (0.01 deals per million) and South Africa (no deals). A total of 92.5% of all urban tech deals in 2018 and 2019 funded G20 based companies, compared with 'only' 80% of world gross domestic product (GDP).

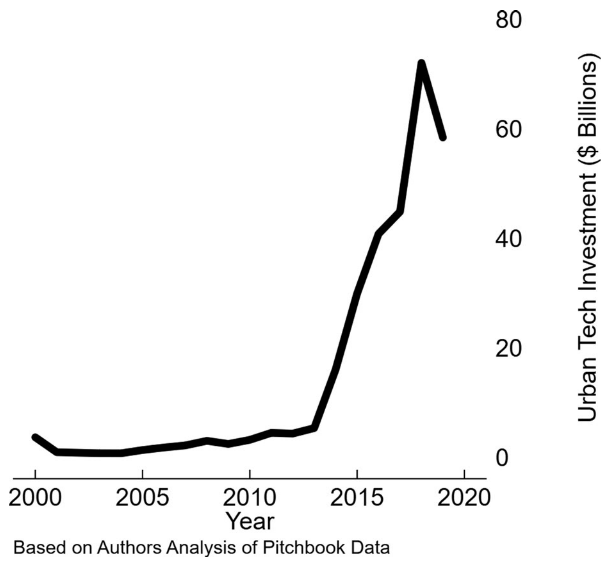

Figure 3. Global urban tech investment, 2010–19.

Urban tech clusters

Venture capital investment is highly localized within the advanced G20 countries. Table 1 shows the regions that received the most urban tech venture investments between 2010 and 2019 and the corresponding deals, deal share and revenue – which is displayed as a bar chart. The top 40 metros for deal volume account for just 8% of global population, 26% of global economic activity and 33% of urban tech deals.

The last column of Table 1 shows the percentage of all local deals that are mega-deals, by which we mean they involved at least US$25 million in investment. Roughly one-third of deals in Beijing, Shanghai and Shenzhen match this description. Beijing's mega-deals propel it to be the top urban tech region in terms of reported investment. A total of 18% of deals in São Paolo are megadeals (Berlin = 15%); The Bay Area and Delhi (5%). Fewer than 5% of Paris and London deals are extremely large. Again, the top metros are very likely to be existing US tech poles or capitals/primate centres of the countries. We do not see high urban tech activity in traditionally industrial areas of North America and Europe.

Regression findings

We now turn to the findings of our regression models. Urban tech deals are more common in larger, denser metros with educational assets. Table 2 highlights key trends over the last two years and over the 10-year period. Almost half of all 2018–19 deals involve firms that are based in metros with top 500 global universities according to the Times World University Rankings (2018) and 27% are based in metros with more than one such institution. There are 320 leading global cities (metro and non-metro) with these top institutions, and the population of these is a mere 8 percent of the global total. Urban tech deals are clustered among the 28 largest extended mega-region agglomerations (Adler et al., 2020). Roughly 34% of urban tech deals flow to mega-region firms, well more than the 23% of overall economic activity that takes place in these areas. Urban tech deals are somewhat more concentrated in large metros (with more than 5 and 10 million people), national capitals and primate cities (cities that are the largest in their nations) than you would predict based on population and economic activity. In the last part of the decade, deals were significantly more likely to go to firms in mega-regions and top university regions, but they were not more likely to be in large or capital regions.

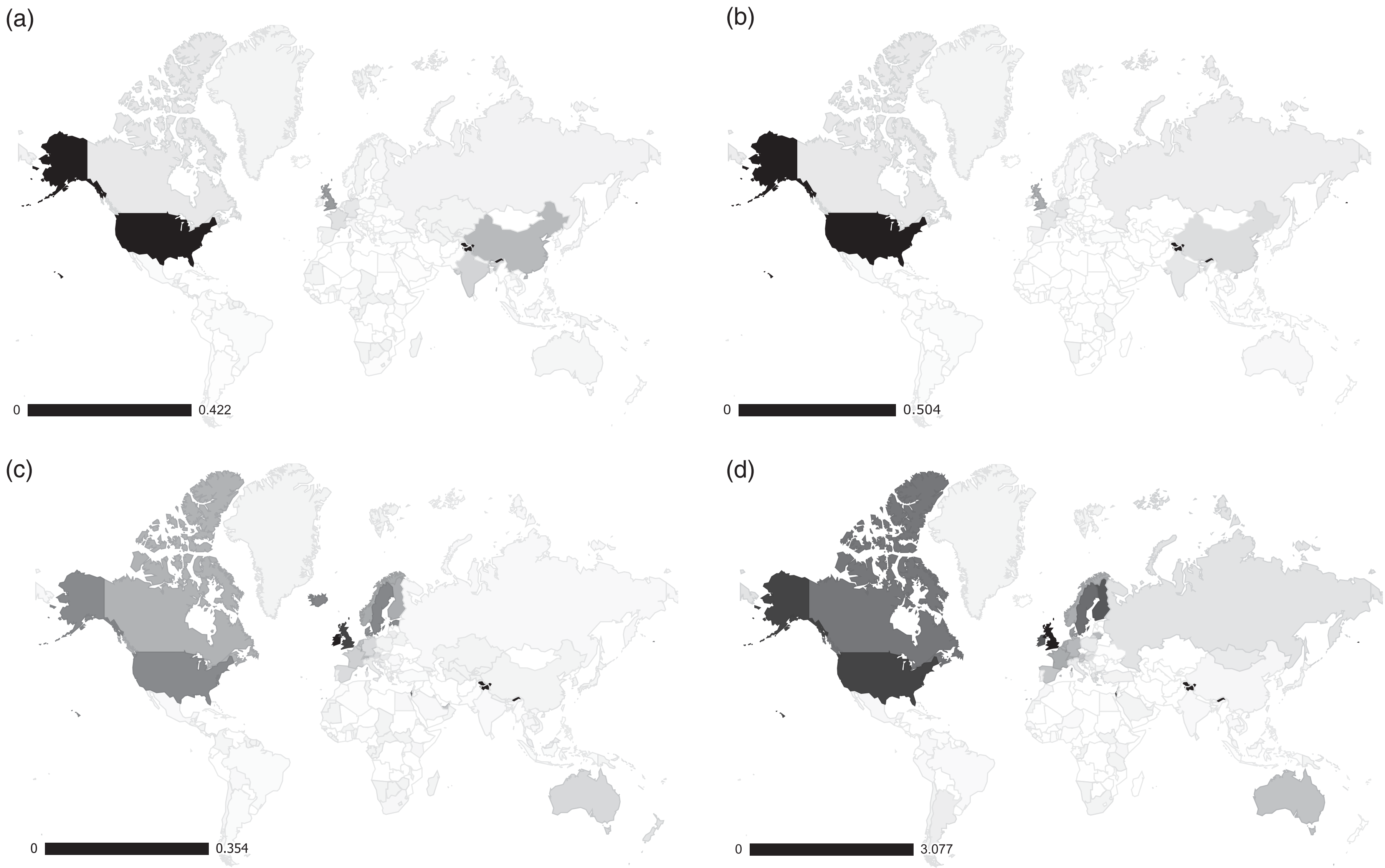

Figure 4. Global distribution of urban tech deals.
Note: (a) Urban tech deal share, 2010–11; (b) urban tech deal share, 2018–19; (c) urban tech deals per capita, 2010–11; and (d) urban tech deals per capita, 2018–19.

Table 1. Leading urban tech clusters, 2010–19.

Rank	Metro	Deals (*n*)	Global (%)	Investment (US$ '000s)	Mega-deals (%)
1	San Francisco, CA, USA	1527	4.86%	49,011	15.26%
2	New York, USA	1085	3.45%	22,080	11.71%
3	London, UK	908	2.89%	5205	3.08%
4	Los Angeles, CA, USA	537	1.71%	10,631	11.17%
5	San Jose, CA, USA	503	1.60%	9454	15.11%
6	Beijing, China	454	1.44%	62,498	32.82%
7	Paris, France	436	1.39%	2174	2.52%
8	Boston, MA, USA	411	1.31%	3898	9.00%
9	Seattle, WA, USA	279	0.89%	1971	6.09%
10	Bangalore, India	279	0.89%	7369	14.70%
11	Delhi, India	253	0.80%	10,819	15.42%
12	Shanghai, China	250	0.80%	24,514	34.00%
13	Chicago, IL, USA	232	0.74%	877	2.59%
14	Washington, DC, USA	226	0.72%	1589	4.42%
15	Austin, TX, USA	193	0.61%	1934	9.84%
16	Berlin, Germany	192	0.61%	5504	18.75%
17	Tel Aviv, Israel	165	0.52%	2926	13.33%
18	Moscow, Russia	149	0.47%	466	2.68%
19	Barcelona, Spain	142	0.45%	795	3.52%
20	Denver, CO, USA	135	0.43%	1037	8.89%
21	Singapore, Singapore	129	0.41%	9818	13.18%
22	San Diego, CA, USA	123	0.39%	883	3.25%
23	Dallas, TX, USA	121	0.38%	672	3.31%
24	Atlanta, GA, USA	117	0.37%	732	5.98%
25	Toronto, ON, Canada	111	0.35%	699	6.31%
26	Tokyo, Japan	110	0.35%	746	4.55%
27	Boulder, CO, USA	107	0.34%	567	8.41%
28	Mumbai, India	105	0.33%	400	1.90%
29	Miami, FL, USA	100	0.32%	1103	1.00%
30	Portland, OR, USA	99	0.31%	581	2.02%
31	Stockholm, Sweden	93	0.30%	422	4.30%
32	Philadelphia, PA, USA	91	0.29%	1105	6.59%
33	Shenzhen, China	90	0.29%	1770	25.56%
34	Montreal, QC, Canada	85	0.27%	563	4.71%
35	Vancouver, BC, Canada	84	0.27%	265	0.00%
36	Sydney, NSW, Australia	82	0.26%	237	1.22%
37	São Paulo, Brazil	77	0.24%	1365	18.18%
38	Houston, TX, USA	76	0.24%	278	1.32%
39	Madrid, Spain	76	0.24%	663	6.58%
40	Amsterdam, the Netherlands	75	0.24%	836	8.00%

These variables are highly correlated, making it hard to determine the relative impact of any individual characteristic. In Table 3, we isolate the specific relationships between these attributes, metropolitan GDP (from Bouchet et al., 2018) and urban tech financing, again using linear regression analysis. In these models, we take the natural log of deals and investment amount and attempt to model metro variation in these measures. Our regression model includes the 202 metros that are among the largest economies according to the Brookings Institute's Global Metro Monitor (Bouchet et al., 2018) and also hosted at least one venture capital deal (in any industry) between 2010 and 2019. This group includes the largest global cities but also traditionally industrial areas such as Cleveland, Detroit, Birmingham and Manchester, and Lille. In most of our regression models, the sample size is 202. Before drilling down to the venture ecosystem level, we review global trends.

Table 2. Distribution of urban tech deals by metro type.

Type of place	Deals 2018–19	Share 2018–19 (%)	Deals 2010–19	Share 2010–19 (%)
1+ Leading universities	2420	46.10%	5661	36.00%
Megaregions	1806	34.40%	4275	27.20%
5 Million+ metros	1438	27.40%	3988	25.40%
2+ Leading universities	1432	27.30%	3658	23.30%
Primate metros	1059	20.20%	3033	19.30%
10 Million+ metros	966	18.40%	2930	18.60%
National capitals	787	15.00%	2332	14.80%

Roughly 30% of regional variation in urban tech deals and 25% of total financing is explained by the full complement of these variables. Regional GDP and the count of top 500 universities are significant in each model. Explanatory power is improved modestly when megaregion and national capital indicators are added.

In the full model, an additional US$1 trillion in regional economic activity is associated with 440 more deals over the decade and US$1.5 billion more in urban tech investment. Each additional elite university is associated with 2.5 additional deals and US$270 million in investment. Metro presence in a megaregion is only significant for deals, and not investment amount. Megaregion metros have 3.9 more urban tech deals on average. Population is negatively but not significantly related to outcomes among this roster of large metros. Of course, large cities are much more likely to form the top 300 economies in the world, so this result should be read with caution, but regional income does seem to drive urban tech venture activity more than absolute size. The national capital term is negative and insignificant. The primate city term was excluded from the model due to its high correlation with the national capital one.

Given the modest relationship between urban tech deals, economic output and the presence of research universities, it is worth asking whether urban tech clusters differ from other areas with high venture capital investment. In other words: Is the geography of urban tech unique or does it follow the pattern of high-tech venture capital investment more broadly?

In Table 4, we add to the previous models, a count of non-urban tech deals and investment, respectively. These represent all venture capital deals on Pitchbook outside of urban tech. This dramatically improves the power of the models: 50% of deals and 30% of investment value can now be explained. Also, the new variable now dominates the model – it is the only significant term on the deal side, and it is much stronger than any other variable on the investment side. This clearly suggests that the geography urban tech start-ups is statistically indistinguishable from start-up geography generally.

Table 3. Predicting global urban tech venture activity.

	Dependent variable			
	Logged deal (1)	Count 2010–19 (2)	Logged billions (3)	US$ 2010–19 (4)
Population (millions)	−0.017	−0.010	−0.052*	−0.041
	(0.019)	(0.020)	(0.029)	(0.030)
Metro GDP (trillions)	1.688	1.437***	3.093	2.795
	(0.548)	(0.559)	(0.846)	(0.866)
Top universities	0.230	0.225	0.247	0.244
	(0.045)	(0.045)	(0.069)	(0.070)
Capital		−0.078		−0.159
		(0.199)		(0.309)
Mega		0.333*		0.375
		(0.171)		(0.265)
Constant	0.882	0.800	1.063	0.977
	(0.116)	(0.125)	(0.179)	(0.194)
Observations	202	202	202	202
R^2	0.324	0.338	0.259	0.268
Adjusted R^2	0.314	0.321	0.247	0.249
Residual SE	1.113 (d.f. = 198)	1.107 (d.f. = 196)	1.718 (d.f. = 198)	1.716 (d.f. = 196)

Table 4. Predicting global urban tech venture activity controlling for other forms of venture capital.

	Dependent variable	
	Logged deal count (1)	Logged investment amount (2)
Population (millions)	0.004	−0.059
	(0.020)	(0.035)
Metro GDP (billions)	0.627	2.349**
	(0.570)	(0.978)
Top universities	0.067	0.155**
	(0.042)	(0.071)
Venture capital	−0.240	−0.326
	(0.186)	(0.329)
Mega-deals	0.032	−0.052
	(0.163)	(0.291)
Non-urban tech deals 2015–17	0.001***	
	(0.0002)	
Non-urban tech value 2015–17		0.0001***
		(0.00001)
Constant	1.366	1.756
	(0.128)	(0.227)
Observations	146	146
R^2	0.504	0.368
Adjusted R^2	0.483	0.341
Residual SE (d.f. = 139)	0.916	1.621
F-statistic (d.f. = 6; 139)	23.541	13.478

As a robustness check, we decomposed the preceding investment activity measures into subsectors of urban tech: mobility tech, non-mobility and core tech, and non-core urban tech. Our results do not change either in terms of the significance of terms or the effect sizes. This result rebuffs the intuition that more industrially oriented urban tech production is more likely to be found in traditional industrial cities.

DISCUSSION AND CONCLUSIONS

Our research has aimed to uncover the geography of a new suite of urban technologies. We used detailed microdata to define urban tech, map its distribution among global metropolitan regions and explain this spatial pattern. We argued that urban tech is an emerging technology sector that is directed toward addressing the problems of urban agglomeration. Our analysis has centred on venture capital activity, which we argue to be a superior indicator of local commercialized innovation.

We find urban tech activity to be highly concentrated in a relatively small number of cities across the world. The roster of leading urban tech clusters is somewhat diverse in that it includes cities and metro regions across North America, Europe and Asia. We further find urban tech innovation to be clustered in two types of places: leading tech hubs such as the San Francisco Bay Area and very large global cities such as New York, London and Beijing.

Furthermore, we sought to identify several key geographical determinants of urban tech. First, urban tech is associated with high tech venture capital investment more broadly. Our analysis finds that a good deal of urban tech activity is explained by venture capital investment across the board. The rise of urban tech has not, at least according to this analysis, led to the emergence of new technology centres, but is a product mainly of existing tech geographies. This result echoes prior studies which have found that venture capital generally concentrates in a small number of centres (Adler et al., 2019; Carlino & Kerr, 2015; Chen et al., 2010).

Urban tech is also, and relatedly, associated with the presence of leading-edge universities. This is in line with prior literature which identifies research universities as key components of high-tech ecosystems and is anticipatable based on the existing literature. Universities are direct producers of technological know-how, much of which is tacit and localized (Bramwell & Wolfe, 2008) and these activities can directly lead to spinoff firm formation (Shane, 2004). Universities are also a more general mechanism for attracting talent or human capital, and for the mixing and matching of technological and managerial talent (Colombo & Grilli, 2010; Feeser & Willard, 1990). While Pitchbook data do not permit investigation of whether spinoffs are driving this result, the university/urban tech correlation is strong enough to warrant further investigation. An in-depth study might try to isolate the channels through which a university effect might operate.

Future research can furthermore assess the source of big city advantages in urban tech. Larger, wealthier and more extensive cities may be better nurseries of new organizations due to their diverse economic structures (Duranton & Puga, 2004; Jacobs, 1969). These global cities are also said to be advanced producer service centres (Beaverstock et al., 1999), meaning specialized areas for both management and finance. But there are also demand-sided factors because larger urban areas are home to the sorts of opportunities, problems, and challenges, such as congestion and housing affordability, that urban technologies aim to address.

More research is needed into the factors which shape the rise of new urban tech hubs. Our research shows that certain places have gained high tech capability over time. New York and London are much more viable players in urban tech than they were in earlier technology sectors such as semiconductors or computer hardware. And leading urban tech centres have emerged in Chinese cities, particularly Beijing, which is the leading urban tech centre in investment terms. Why and how do these new centres emerge? Is it a function of size and scale? Is it relational, that is connected to the flows of people and capital between certain regions? Saxenian (2007) emphasizes the importance of 'brain circulation' between the San Francisco

Bay Area and Taiwan to the latter's emergence as an innovation centre.

Our research suggests that traditional industrial centres (Bellandi et al., 2020; De Propris & Bailey, 2020) lag in terms of technology formation, but this may be a function of which firms are in the sample. It is possible that traditional industrial regions are more fertile sites for incumbent (i.e., non-start-up) urban tech firms such as Bombardier. Future studies could explore the activities of large incumbent, multinational firms in urban tech, looking for evidence of territorial servitization or similar phenomena. We might expect for large firms to care less about their external environments because they are already globally connected and talent-attracting entities with considerable internal human capital and knowledge-generating capabilities. On the other hand, the start-up firms studied here should be more interested in tapping into the external labour pool and technology base.

Future research should also investigate the sources of the venture financing advantage among leading tech hubs and large global cities. The source of such specialization may be related to path dependence among leading venture capitalists – a venture firm that has succeeded in funding formerly innovative sectors has an advantage with new ones. However, there may also be other, deeper sources of venture finance agglomeration economies that are outside of the scope of the present study. These would include the presence of social or deal-making capital (Feldman & Zoller, 2016), the in-migration of aspiring innovators (Bahar et al., 2020), the endowment of local universities (Adams, 2005), among other factors. We hope that subsequent research can disentangle all these effects and do so on a global scale.

Finally, we expect the late and post-COVID-19 period to be ripe for the growth of urban tech specifically. The advent of new work-from-home routines would seem to increase demand for such technologies. Then again, these routines may also relieve cities of some of the pre-pandemic congestion that urban tech is supposed to address. Indeed, there is no shortage of directions for future research on the geography of urban tech.

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