Explaining Urban Order:
The Autocratic Origins of Africa's City Street Networks*

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Abstract

I connect the political incentives of state leaders to the physical geometry of urban built environments. Drawing on a novel combination of street network data, archival maps, and satellite imagery, I build upon classic claims that autocratic regimes order urban space, rendering society more legible through the production of gridded streets. Backdating the construction of 1.5 million streets across a sample of African cities, I show that more ordered, gridded urban neighborhoods emerge under more autocratic post-colonial regimes. But rather than a conscious effort to increase society's legibility through urban design, evidence on mechanisms is more consistent with urban order emerging as a side-effect of more general patronage strategies autocrats use to placate critical subsets of the urban population. The paper demonstrates that efforts to intervene on the built environment represent an underexplored element of both autocratic and urban politics in the developing world.

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Authoritarian survival depends on controlling urban populations (Bates 1981, Ades and Glaeser 1995, Wallace 2014, Ballard-Rosa 2020, Beissinger 2022). Autocracies pursue political control through a range of tools, including both violent coercion of dissent and non-violent cooptation through distribution (Frantz and Kendall-Taylor 2014, Albertus et al. 2019, Hassan et al. 2022). These strategies share that they are top-down attempts to change society's behavior (Migdal 1988). The hearts and minds of citizens are not the only canvas on which these efforts have visible effects, however; some also shape the physical, material spaces in which state and society interact.

I link regime strategies of political control to urban form and the *built environment* – the architectures and designs structuring urban life. Built environments are often path dependent, with high transaction costs to redevelopment (Kostof 1991). Legacies of past efforts at political control can become frozen into urban landscapes, leaving a record visible from the present through which to diagnose historical regime strategies that might otherwise be hard to observe in hindsight. Built environments are also an important, but understudied, determinant of political behavior (Nathan and Sands 2023), with a nascent literature documenting how urban architectures and designs affect protest (Zhao 1998, Bayat 2010, Patel 2014, Sharp and Panetta 2016, Schwedler 2022) and other forms of political participation (Gade 2020, Bollen 2022, Nathan 2024). Understanding why built environments take the forms they do is important for developing a more complete picture of how regimes control urban populations and how urban populations, in turn, resist or assent to their rule.

I ague that autocracies have stronger imperatives to intervene on urban built environments than democracies. In doing so, they are more likely to oversee the emergence of ordered – that is, more *legible* – urban spaces. Scott (1998) famously describes interventions by autocrats to impose legible designs on cities explicitly to enable coercive repression of protest, a dynamic exemplified by Georges-Eugene Haussmann's redesign of Paris for Napoleon III after France's 1848 Revolution. But autocratic efforts at political control can also affect urban design in less explicit ways: strategies of selective autocratic distribution aimed instead at coopting support (Rosenfeld 2021) also systematically change built environments as a byproduct of the physical construction that occurs with state spending on some patronage goods. Downstream effects on the legibility of society to the state in affected areas may be similar, but the logic motivating regime strategy is different. Holding regime threats fixed, I argue that the latter mechanism is more likely in low capacity states, identifying a pathway through which even ostensibly "weak" states still can have meaningful effects on urban design.

I examine the *griddedness* of city streets amidst Sub-Saharan Africa's rapid urbanization. The rectilinear grid is the world's most common planned urban design (Kostof 1991), as well as Scott's (1998) central indicator of a legible built environment rendered more controllable by a state. Pairing substantial variation in griddedness (Boeing 2021) with substantial variation in regime type within historically-similar cases,[1] African cities allow for a direct test of the claim that regime type affects built environments in a setting that better typifies experiences of contemporary autocratic rule – most autocracies are now in low- and middle-income countries – than more classic examples of city-building in high capacity states like 19th century France (Gould 1995, Scott 1998).

African states provide an especially hard test for an effect of regime type because they are typically argued to have quintessentially limited capacity (Herbst 2000). Gridded streets only emerge with top-down planning (Kostof 1991), but literature on African urbanization stresses its unregulated nature (Freund 2007, Murray 2011, UN-Habitat 2014, Deuskar 2022), especially after structural adjustment tied the hands of planning bureaucracies (Yeboah 2000, Arku 2009*b*). And yet, some African cities have intricately planned neighborhoods, and city planning has been a primary endeavor of some leaders (Arku 2009*a*, Pitcher 2017), implying a more complex relationship between regime goals and urban design than simplistic narratives of state weakness allow.

I draw on systematic data on the complete street networks of the 1,001 largest cities in Sub-Saharan Africa. Deploying methodological tools introduced by Boeing (2017, 2019, 2021), I

[1] Most large African cities first emerged around the same time during colonial rule and then rapidly grew over similar decades of the post-colonial period. A global dataset would instead compare cities designed centuries apart under very different technological circumstances and include regions with limited variation in contemporary regime type, precluding the research design below.

use OpenStreetMap to measure the griddedness of streets.[2] After presenting city-level descriptive evidence, I turn to a newly digitized and geo-referenced collection of historical city maps – a combination of archival sources and satellite imagery – to backdate the construction of each of 1.5 million individual street segments across the over 7,500 neighborhoods that comprise a randomly selected set of 36 large African cities. I estimate how political and economic conditions at the time each neighborhood was initially built explain neighborhood-level legibility.

Urban legibility is an outcome of authoritarianism: across the post-colonial period, the degree of autocracy when a neighborhood was built predicts that neighborhood's griddedness; neighborhoods in the same cities built under more democratic regimes instead have more tangled, disordered layouts, consistent with unplanned growth. I account for topographical, environmental, and other features, such as macro-level property rights institutions and colonial and pre-colonial legacies, including via city fixed effects that control for time-invariant city- and national-level confounders.

There is little evidence that these patterns are due to autocrats' explicit pursuit of legibility to enable coercive control: leveraging neighborhoods' spatial distance from state power centers, temporal distance from contentious episodes, and interconnectedness with boulevards along which troops can most easily move, I show that the construction of legible neighborhoods does not appear motivated by attempts to prevent protest and unrest. Instead, I find that legible layouts emerge more as a byproduct of a form of distributive politics particularly common in autocracies: the provision of state housing as patronage to buy off key subsets of the urban population (Croese and Pitcher 2019, Rosenfeld 2021). While housing is a useful tool for autocrats, I suggest that leaders in electoral regimes, seeking support from a far wider set of residents in the face of an enlarged selectorate, instead often find it more efficient to engage in "forbearance" (Fox and Goodfellow 2016, Holland 2017), tolerating disordered urban growth rather than directly investing in housing. I test this mechanism using "medium-N" case studies from which I code a new dataset on the

[2] `https://www.openstreetmap.org/`. Importantly, by drawing on both remote sensing data and crowd-sourced submissions, OpenStreetMap includes informal neighborhoods and unpaved vehicular roads.

history of state housing across 20 of my sampled cities. I show that state housing is more likely under autocratic regimes and that the historical timing of state construction predicts when gridded neighborhoods emerge. Most importantly, I show that the positive relationship between autocracy and grids holds only in periods that regimes engaged in direct housing development.

Rather than constraining their ability to affect urban form, the fact that many African states have limited capacity appears central both to why autocrats focus on housing more than democrats and why their housing investments have legible designs. Capacity constrains electoral regimes' ability to meet mass demands for housing, incentivizing strategies of forbearance and unregulated growth. The more targeted developments pursued by autocrats often entail laying out new streets. But instead of a conscious tool of control, rectilinear grids are an especially easy-to-build layout – a default for budget-constrained builders. If political imperatives to build housing are strong enough, even very poor states can concentrate sufficient capacity in "pockets" of bureaucratic effectiveness (Geddes 1994, McDonnell 2020) within specific agencies tasked with the construction of specific neighborhoods. Indeed, I show that the relationship between autocracy and legibility does not vary with, and legibility does not correlate with, measures of state capacity or resource access. There is also no time trend in legibility, including before versus after structural adjustment reforms usually said to have limited states' ability to plan.

This paper makes several contributions. First, I help turn the attention of empirical political science to the design of built environments.[3] My focus on *design itself* as an outcome is distinct from more established literatures on why physical structures like housing or roads are built, but not on what they look like. Such a shift is important for scholars of urban politics (Post 2018): cities are not just agglomerations of people, but also of material things – the buildings and streets that structure social interactions, contact with the state, and possibilities for collective action. Yet despite significant research from other fields showing that built designs affect behavior (e.g., Jacobs

[3]For a related shift in political theory, see Bell and Zacka (2020).

1961, Grannis 1998, Zhao 1998), political scientists rarely consider them.

Second, I provide the most systematic exploration to date of Scott's (1998) observations about a link between authoritarianism and legible city-building, helping demonstrate that studying the built environment provides a viable window into better understanding autocrats' broader toolkits for political control (Frantz and Kendall-Taylor 2014, Hassan et al. 2022). I expand upon the mechanisms implicit in Scott's (1998) account, however, theorizing how urban legibility can be produced via a broader set of autocratic behaviors and across a greater range of state capacities.

Finally, I contribute to studies of urbanization and the state in Africa. My evidence that even autocrats in some of Africa's poorest, lowest-capacity post-colonial states – including after structural adjustment – still alter urban built environments at scale, while relatively more democratic leaders seemingly chose not to, contrasts with more conventional accounts of African urbanization (e.g., Freund 2007, UN-Habitat 2014), suggesting they overstate the constraints neoliberal policy shifts created for urban planning. Instead, I reinforce an on-going theoretical reevaluation of canonical claims about state capacity: observations that states are failing to intervene in a particular domain are not necessarily evidence of inherent weakness, as most commonly interpreted (Herbst 2000), but instead can indicate that state leaders benefit from not intervening and are endogenously under-exercising latent power (Boone 2003, Holland 2017, Hassan 2020, Nathan 2023).

1 The origins of urban order

How does an ordered, legible built environment affect politics? And, crucially, why are some built environments more ordered and legible? I discuss theoretical implications of each question. I address alternative, more apolitical, explanations for urban order in a subsequent section.

1.1 Why focus on built environments?

The built environment defines the terrain on which two interactions critical for urban politics occur: interactions between state and society, and among society. Political impacts can operate through either channel. Scott (1998) exemplifies the first, connecting built environments to his broader claim that a state's ability to interact with society is a function of society's legibility to external observers: the tangled, disordered layouts that characterize spontaneous urban growth create physical and informational barriers to state penetration, while ordered designs, such as the rectilinear grid, increase interpretability, enabling state intervention.

A second literature shows instead that built environments affect politics by shaping residents' interactions with each other. By channeling movement – where people congregate and how they navigate space – the built environment creates social networks, determining who meets and interacts (e.g., Festinger et al. 1950, Jacobs 1961, Hillier et al. 1993, Grannis 1998, Small and Adler 2019). In turn, these ties drive collective action, with scholars of contentious politics linking built designs to urban protest. Zhao (1998), for example, shows that major dynamics of Beijing's Tiananmen uprising grew from the architecture of university campuses, while Gade (2020) explains Palestinian mobilization through the spatial arrangement of security checkpoints.[4] Most directly for the analyses below, Nathan (2024) connects the griddedness of neighborhood streets in urban Ghana to reduced political participation, mediated through lower social capital in neighborhoods where ordered designs reduce quotidian encounters among neighbors.

Both perspectives raise an important antecedent research question at the heart of this paper: why do some urban areas have more ordered designs to begin with? The answer is especially important for understanding the potential effects of built environments because the process through which designs emerge could be endogenous to the political dynamics these studies seek to explain.

[4]For related examples, see Bayat (2010), Patel (2014), Sharp and Panetta (2016), or Schwedler (2022).

1.2 Urban order and autocracy

Ordered street layouts do not emerge spontaneously. They require top-down coordination, typically by the state (Kostof 1991). I expect that autocracies have strong incentives to intervene in cities in ways that produce legible designs. This could be a purposeful attempt to use design as a coercive tool. Alternatively, changes to urban order could emerge indirectly as autocracies intervene on built environments while deploying less coercive strategies to build support. The difference between these motivations emerges from considering the broader menu of strategies – tools in a "toolkit" (Frantz and Kendall-Taylor 2014) – available to regimes (Hassan et al. 2022). Choices among these strategies are best theorized as a combined function of regime threats and state capacity.

Cities present the more serious threat than rural areas to many autocracies (Bates 1981, Wallace 2014, Beissinger 2022), at both elite and popular levels. Cities, especially capitals, are both where the elites in an autocracy's narrow selectorate (Bueno de Mesquita et al. 2003) are primarily located and where coup attempts typically unfold (Woldense 2022). At the popular level, cities place citizens near nodes of state power, where unrest can cascade quickly into over-running state institutions (Beissinger 2022).[5] High urban population densities also put large numbers of potential opponents in close contact, facilitating collective action. By contrast, rural populations often have lower capacity for contention both because they are more dispersed – increasing coordination costs – and because they are more likely to remain enmeshed in hierarchical relationships with local notables with whom regimes can strike deals for rural acquiescence (Bates 1981, Boone 2003, Riedl 2014).

Urban elite and popular threats are closely reinforcing: relatively elite segments of society – both top-level political elites and wealthier, educated, "middle class" subsets of the population – play key roles in initiating and coordinating broader mass mobilization (Hassan 2020, Rosenfeld 2021). In turn, mass urban protest often creates the moments of uncertainty in which elite coup

[5] Under prevailing international norms, seizing institutions in the capital can be sufficient for a new government to become recognized (Herbst 2000).

plots crystalize (Casper and Tyson 2014), while popular mobilization during coup attempts helps determine whether they succeed (Singh 2014).

Scott (1998) adds to this list of threats that it is specifically the disorder of many urban built environments – and society's resulting illegibility – that enhances the risk of popular protest by reducing the efficiency of the coercive tools available to regimes. He describes autocrats purposefully (re)designing cities in grand fashion *because* the more regularized designs they impose make coercive control "vastly simpler" (Scott 1998, 55): gridded streets facilitate quickly locating dissidents or moving in security forces to repress protesters.[6] These interventions go hand in hand with enforcement against unplanned growth: Wallace (2014) similarly details Chinese state efforts to proactively clear unplanned neighborhoods to preempt illegibility.

The coercive weaponization of design at sufficiently wide scale to forestall mass protest requires high state capacity. Moreover, with meaningful elections, regime threats shift and the imperative for urban order decreases. Illustrating these twin scope conditions, Scott (1998) quotes Mumford (1961, 393) that an ordered plan requires "an architectural despot, working for an absolute ruler" (103). Scott's (1998) motivating example of 19th-century Paris is from a quintessentially strong state, and involved large-scale displacement of existing land users, an expensive undertaking sure to generate backlash. A despot in a highly-resourced state might afford these costs. More budget-constrained regimes cannot. Relatedly, while democratic regimes may also benefit from the legibility of ordered urban designs – such as through improved ease of service provision and administration – the "representative institutions" that emerge with democratization create an "important barrier" to costly efforts to impose urban legibility by allowing "a resistant society... [to] make its influence felt" and protect the interests of current land users (Scott 1998, 102). The selectorate, and thus size of a minimum winning coalition, increases substantially with democratization (Bueno de Mesquita et al. 2003), rendering regimes both more sensitive to the political risks of

[6] Scott (1998, 62) separately argues that some autocrats also have aesthetic preferences for grids because they project a politically-useful Modernist image, an alternative mechanism I engage below.

upsetting ordinary citizens displaced by redevelopments and elevating the power of rural relative to urban areas. With the median voter often rural (Stasavage 2005) and power decided via the ballot, not coups, urban unrest becomes a lesser threat, disincentivizing costly urban redesigns.[7]

But other tools in autocrats' toolkit also have implications for urban order and are more attractive to less well-resourced states. Rather than pure coercion, many autocracies also address their twin elite and popular urban threats through "urban bias," privileging cities over rural areas through distributive policy to coopt support (Bates 1981, Ades and Glaeser 1995, Wallace 2014, Ballard-Rosa 2020). Bates (1981) documents how Africa's post-independence autocrats used multiple levers to placate urbanites, including artificially lowering urban food prices, subsidizing employment in bloated civil services and state-owned firms, and providing targeted patronage goods.

Housing is a particularly common and effective benefit for autocrats to distribute (Croese and Pitcher 2019, Rosenfeld 2021, Hilbig et al. 2023). Although not unique in these features,[8] housing is an easily-targetable private good scarce in cities, and thus valued greatly by recipients. It is a central example of a revocable clientelist benefit, creating self-enforcing exchanges that are especially attractive to regimes: clients' preferences become aligned with the regime's through clients' expectations they could lose their homes if the regime changes, reducing risks of defection (Albertus et al. 2019, Hicken and Nathan 2020).[9] Autocratic distribution of housing and related access to land is often designed purposefully to limit recipients' "exit options" (Rosenfeld 2021): rather than given titles outright, recipients are often kept dependent on the regime as their landlord or mortgage lender (Pitcher 2017, Hassan and Klaus 2023).[10]

Using housing as a "selective incentive" (Rosenfeld 2021, 6) directly affects built environments

[7] Posner (2005) provides a similar type of claim about how institutionally-induced shifts in the size of minimum winning coalitions affect other domains of political contestation.

[8] State jobs can have similar characteristics, for example (Rosenfeld 2021). It is not clear *ex ante* that jobs are significantly more or less costly to provide; I expect many regimes provide some mix of both to different clients.

[9] This contrasts both with immediately consumable benefits, such as cash, or fully alienable assets, such a land title, around which clientelist commitments are less credible (Hicken and Nathan 2020).

[10] See Albertus (2021) on the broader implications of this "property rights gap."

because, unlike some other types of patronage (e.g., jobs), it explicitly entails physical construction. The architects designing new state developments need not have explicit agendas to coerce protesters via legible design. While urban planners have employed various designs – including ornate patterns and attempts to simulate "spontaneity" – Kostof (1991) reflects that "the grid... is by far the most common pattern for planned cities in history" (95).[11] Grids are so common because they are typically less complicated, and thus less costly, to construct than more complex designs. In an account of East German state housing – famed for gridded apartment blocks – de Graaf (2017, 41) highlights that "the urban plan [became] a reflection of industrial logistics" not political goals. Satiating demand for housing was a priority of the GDR (Hilbig et al. 2023), and the regime's policing of society may have benefitted from the legibility these designs produced, but the "crane [was] the main architect" of these projects, with decisions about how to space new units determined by considerations like the turning radii of the cranes used for construction (de Graaf 2017, 41), facilitating production on the cheap.

Budget-constrained states – to the extent they build anything – may default to legible layouts. Rendering areas near the downtown urban core more controllable is a crucial goal if design is used to "protest proof" (Collier 1976, Scott 1998, Beissinger 2022). But if a regime's goal is simply to build more housing, construction can be sited wherever is cheapest. "Greenfield" construction converting rural land to new urban use is vastly less expensive and subject to popular backlash than an effort to bulldoze and reorder a city center, as in Paris (Scott 1998). Rather than a broadly high capacity state, building targeted housing benefits simply requires a single agency or parastatal with enough financing to hire a (often foreign) construction company (Gastrow 2020), a surmountable challenge for virtually any state if cooptation is a sufficient priority.

Without any budget or capacity constraint, an autocracy might prefer a grand, legible urban plan

[11] Grids have been observed in pre-modern cities in virtually every world region, and remain common in contemporary cities throughout the world (Stanislawski 1946, Mumford 1961, Grant 2001, Pugh and Rice 2017, Bigon and Hart 2018).

to broadly enable coercion against popular threats. But investing in housing on a more targeted scale can still reap political rewards. Mirroring autocratic strategies elsewhere (Rosenfeld 2021), post-colonial African autocrats typically focused most on coopting elites and the urban middle class, especially state employees, minorities of urban society with the most resources and capacity to mobilize opposition and spark mobilization for democratization (Bates 1981). These relatively elite urbanites are those best positioned to initiate and lead a broader popular urban uprising, such that coopting elite segments of society through targeted patronage is still a helpful first step towards preventing popular threats as well (Hassan 2020).

Regime threats shift similarly in lower-capacity states with the introduction of elections. Using housing as a tool for cooptation becomes less attractive. With leaders now needing support from a broader share of the urban population (Bueno de Mesquita et al. 2003), scaling up housing construction can become prohibitively costly, as hundreds of thousands, if not millions, of voters all demand better homes amidst rapid urbanization (Collier 1976). Elected leaders in lower capacity states may lean more instead on "forbearance" (Holland 2017) via the tacit acceptance of unplanned growth in return for support (Fox and Goodfellow 2016). Studies of electoral politics in urban areas of the developing world detail how dense concentration of (poor) residents in ostensibly illegible, unplanned neighborhoods often become politically attractive to leaders as "vote banks" (Paller 2019, Auerbach 2020), not threatening, allowing leaders to leverage the precarity of informal settlements through clientelism, including by declining to enforce planning rules to create a new more mass-based form of dependency that also helps convert to support (Holland 2017).

In sum, under either mechanism – the weaponization of urban design for coercion or changes to design as a byproduct of cooptation – autocracies have greater incentives to respond to their central urban threat by producing legible built environments. This relationship between regime type and urban order should exist among both high and low capacity states, but for different reasons, with Scott's (1998) account more viable among the highest capacity states, while targeted investments in state housing drive changes in built environments among lower capacity states.

2 Measuring urban order

I evaluate these claims in Sub-Saharan Africa. From the perspective of Scott (1998) or existing Africanist scholarship on urbanization, the generally low levels of capacity in many African states should make them an unlikely setting to find a relationship between regime type and urban legibility. Yet they represent cases in which the alternative mechanism above should fit closely.

In this section, I introduce my measure of urban legibility and provide city-level descriptive statistics. I then demonstrate that legibility is best studied at the neighborhood level and define how I classify neighborhoods. Finally, I detail my approach for back-dating streets.

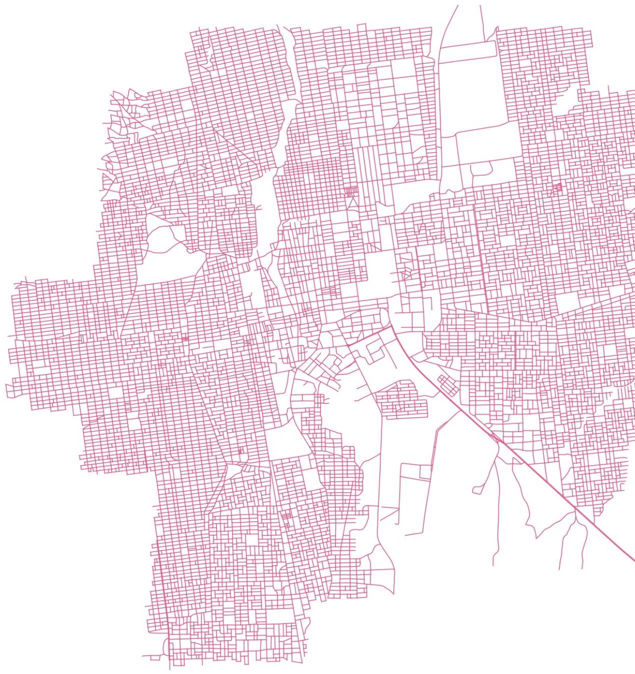
2.1 Orientation order

I study city street networks scraped by Boeing (2021) from OpenStreetMap. I use "city" as shorthand: the data covers urban agglomerations with population greater than 50,000; data for a given "city" corresponds to all built urban area surrounding that urban core, often crossing municipal boundaries.[12] After carefully weeding out a small minority of cities with visibly missing street data,[13] I have data for 1,001 Sub-Saharan African cities across 43 countries. Importantly, the street coverage among the remaining cities is high in part because OSM mapmakers now leverage satellite imagery to trace streets even if they do not appear on official maps. It is thus not the case that this data broadly fails to capture certain types of neighborhoods, such as informal settlements.

The main measure of legibility is "orientation order" (Boeing 2019). It is based on the entropy (chaos) of the compass bearings of streets within a given area. The bearing, ranging from 0° to 360° North, between the two nodes (starting and ending intersections) of each street segment (or

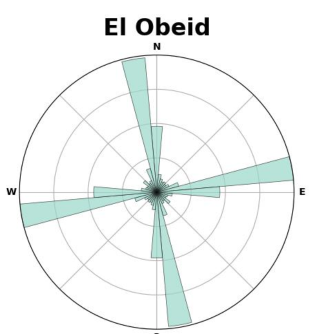
[12]Population estimates and geographic boundaries for each agglomeration are from the European Commission's GHSL Urban Centre Database. See: `https://data.jrc.ec.europa.eu/dataset/53473144-b88c-44bc-b4a3-4583ed1f547e`. I default to their coding for dividing abutting agglomerations (e.g., Pretoria vs. Johannesburg).

[13]This was done by visually inspecting cities against Google satellite data. Badly incomplete data was heavily clustered among small cities (<200K population). Completeness for the remaining cities mostly appears excellent.

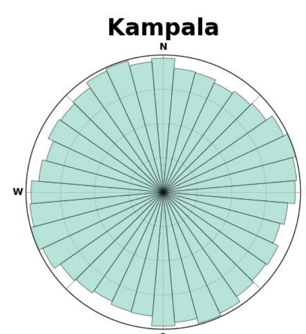


(a) El Obeid, Sudan (high order, O=0.865)

(b) Kampala, Uganda (low order, O=0.003)



(c) El Obeid, Sudan (high order, O=0.865)



(d) Kampala, Uganda (low order, O=0.003)

Figure 1: *Examples of orientation order*: Panels (a) and (b) provide OpenStreetMap data for El Obeid (high order) and Kampala (low). Panels (c) and (d) provide "polar histograms." El Obeid's streets cluster on just four directions, indicating significant griddedness. Kampala's are virtually a uniform distribution over all directions, indicating little griddedness.

edge) is calculated and categorized into 36 evenly sized (10°) bins of the compass. The Shannon's entropy of the resulting distribution of street bearings for area i (H_i) is normalized relative to the entropy of a "perfect grid" (H_g; i.e., one in which all streets point in four right angle directions in equal proportion) to produce a continuous measure of griddedness spanning from 0 (completely ungridded) to 1 (perfect grid), following:

$$O = 1 - (\frac{H_i - H_g}{H_{max} - H_g})^2$$

where H_{max} is the maximum possible value of entropy at this number of bins (36) (Boeing 2019).

An intuitive visualization comes via a "polar histogram" (Boeing 2019). A standard histogram shows a variable's distribution across one dimension; a polar histogram displays the distribution across the 360° of the compass. Cities with gridded streets have most mass concentrated on a few bearings; cities with chaotic streets have their distribution spread across many bearings. Figure 1 shows cities near the extremes of Africa's range and provides corresponding polar histograms: El Obeid, Sudan is among the most gridded, Kampala, Uganda among the least.

2.2 City-level descriptive statistics

African cities fall in the middle of the global range, more disordered than the average North American or East Asian city, but more ordered than the typical European city (Boeing 2021). But there is also significant city-level variation, displayed in Figure 2. I present city-level analyses in the Supporting Information (pg. SI1), but analyses at this level offer misleading estimates of the causes of urban order. The city is not the unit at which order is assigned. No cities are planned at once; they emerge "piecemeal" (Scott 1998, 59), neighborhood by neighborhood, "composites of premeditated and spontaneous segments" (Kostof 1991, 47).

Focusing on a level more aggregated than that at which the outcome of interest is assigned risks the *modifiable areal unit problem* (MAUP), a form of ecological fallacy: correlations in aggregated geographic data regularly do not hold, or even reverse sign, across disaggregated subsets of that

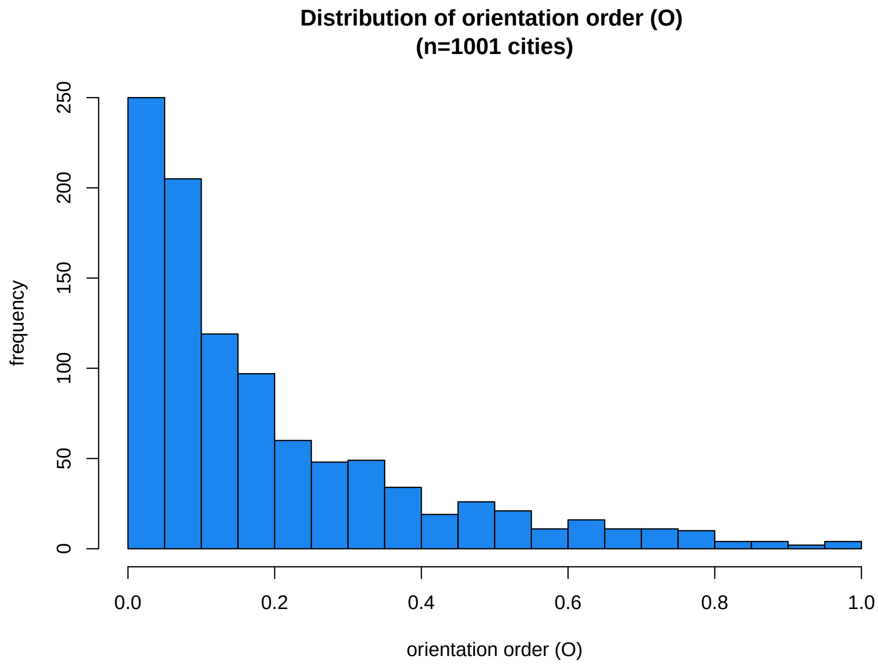


Figure 2: *City-level orientation order across Sub-Saharan Africa.*

same data (Openshaw 1983).[14] Imagine two cities with the same (low) score on O: in the first, most neighborhoods have similarly disordered streets. In the second, most neighborhoods instead have gridded streets, but the streets in each happen to point in different directions as each other, producing low city-level O. For state-society relations (e.g., Scott 1998), the second city is more legible, but a city-level measure cannot distinguish them.[15]

To confirm that the MAUP is a concern, Figure 3 recalculates orientation order at the neighborhood level for 36 cities, with neighborhoods defined and the sample drawn in the manner described below. Figure 3 sorts these cities from most to least ordered, with the red squares indicating city-level orientation order. The box-plots show the distribution of neighborhood-level orientation

[14]For a related example in an African application, see Robinson (2020) on the effects of ethnic diversity measured at local versus national levels.

[15]This is not a contrived example: comparisons of Porto Novo vs. Gaborone or Oyo vs. Cape Town match this hypothetical (Figure 3).

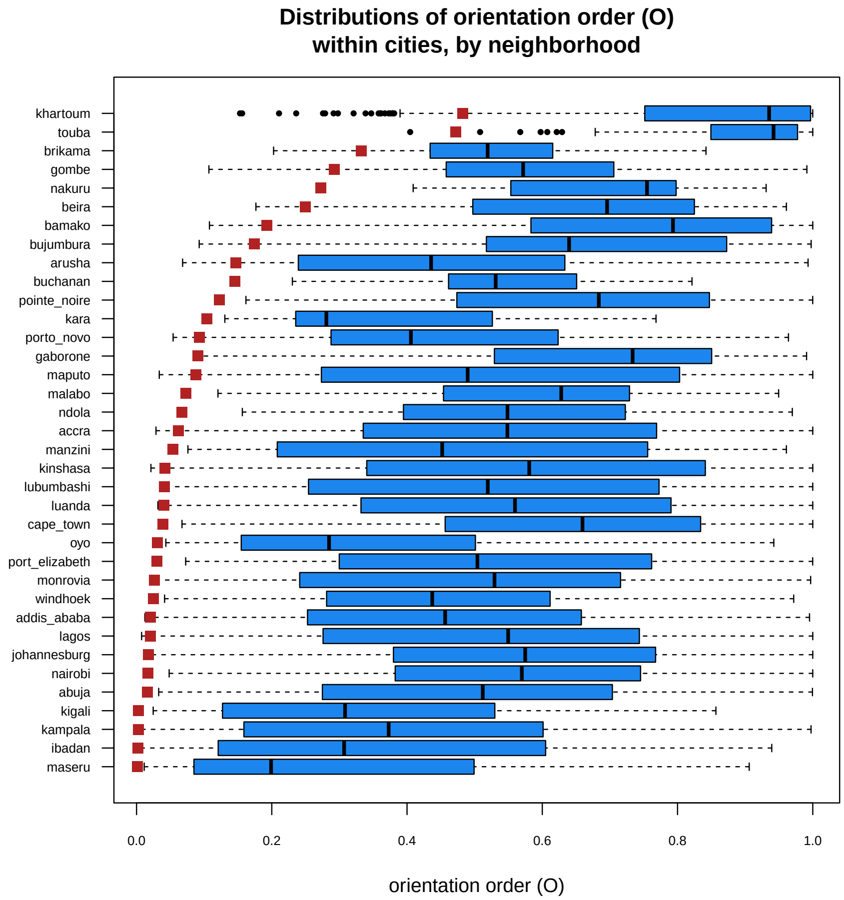


Figure 3: *Orientation order at the neighborhood level*: the red squares indicate the city-level value of orientation order (O); the blue box plots show the distribution at the neighborhood level, with outlier values as black dots. Neighborhoods are defined as "t-communities," following Grannis (1998) (see below).

order, with the central line indicating the median. The city-level values mask enormous intra-city variation, with only limited correspondence between the ranking of each city and that of their median neighborhood. Even Kampala (Figure 1), highly-disordered at a macro-scale, contains ordered neighborhoods within it.

2.3 Identifying "neighborhoods"

I thus turn to the neighborhood – socially meaningful subunits of cities and the most common scale at which decisions about layouts are implemented. Few neighborhoods are legally-defined jurisdictions, however, or consistently labeled on maps. Instead, residents of the same immediate area often have distinct (albeit correlated) "maps in their heads" of their neighborhood (Wong et al. 2012), and the local administrative or census boundaries many scholars use to roughly approximate neighborhoods often have limited correspondence to actual neighborhoods (Grannis 1998, 2009). Regardless, GIS data on intra-urban census boundaries or micro-level administrative units (e.g., wards) at a comparable scale is not available for almost all African cities.

I instead leverage the fine-grained features of OpenStreetMap to deploy a consistent and reproducible approximation of neighborhoods that is more likely than administrative boundaries to correlate with meaningful neighborhoods. Grannis (1998, 2009) demonstrates that the social ties associated conceptually with a neighborhood can be highly-concentrated among residents in self-contained networks of mutually walkable residential streets not subdivided by major boundaries, such as main roads. He proposes defining neighborhoods as "t-communities," where "t" stands for "tertiary streets": small residential streets that are not the major "primary" or "secondary" roads in a city. In this definition, a neighborhood (t-community) is any subgraph of the larger city street network with mutually-connected edges (streets) that do not cross a major road or other similar physical boundary (e.g., railroad tracks, river, drainage canal).

OpenStreetMap categorizes each street segment using a similar scheme as Grannis (1998, 2009), separating residential streets from larger roads. The data also marks bridges, railroads, rivers, and similar features. I subset to residential streets, drop those that intersect a major road or related boundary (e.g., river, bridge), and then split the network into its mutually-connected subgraphs.[16] As an example, Figure 4 displays four t-communities from Accra, Ghana. These

[16]To ensure data quality, research assistants first manually corrected some errors in OpenStreetMap's classifications of

subgraphs have striking face-validity as approximations of neighborhoods.[17] They also match the scale at which urban planning occurs: for example, the neighborhood in panel (a) – Korle Gonno – was a planned development in the colonial period, already visible on maps from the 1920s. I then recalculate orientation order (O) at the neighborhood (t-community) level, as also shown in Figure 4. To calculate O, I first restrict to neighborhoods that contain 10 or more nodes (street intersections) because O becomes mechanically high if calculated over very small sets of streets.[18]

2.4 "Carbon dating" street segments

The final step is to measure political and economic conditions at the time each neighborhood was built. This is possible because most streets are *path dependent*, in a very literal sense: once streets are laid out and buildings built, there are high transaction costs to re-routing them.

This is not a claim that demolition and redevelopment never occurs, but only that, on average, most streets "stick" because it becomes too costly to replace them. With greenfield development more common in African cities overall than infill redevelopment (Angel et al. 2016), most new construction involves laying out new streets, not re-routing old ones. When infill development does occur, it most often involves replacing buildings, not the streets the buildings are on. There are of course also accounts in the literature of full-scale neighborhood demolitions, especially "slum clearing" (Klopp 2008). But this case study literature is quite purposefully sampled on the dependent variable and the vast majority of Africa's urban neighborhoods do not have such a history.[19] Path dependence remains a reasonable assumption for most urban streets.

Present-day street networks can then be viewed analogously to "geological bands": just as dif-

physical boundaries (e.g., bridges, railroad crossings).

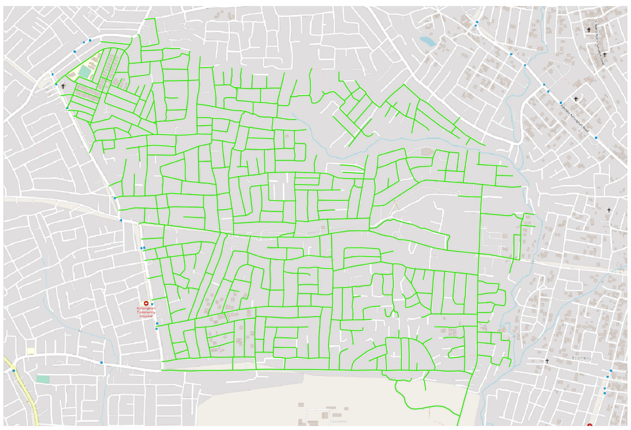
[17] In survey data for a companion paper, I validate that t-communities provide a good approximation of perceived neighborhood boundaries (pg. SI1).

[18] As there are fewer street segments, there is a lower ceiling on how much their bearings can vary across 10° compass bins (e.g., 2 streets only ever occupy 4 bins). 10 is an arbitrary cutoff, but was selected prior to analysis; the results are robust to similar cutoffs (e.g., 9 vs. 11). All analyses also control for t-community size (number of nodes).

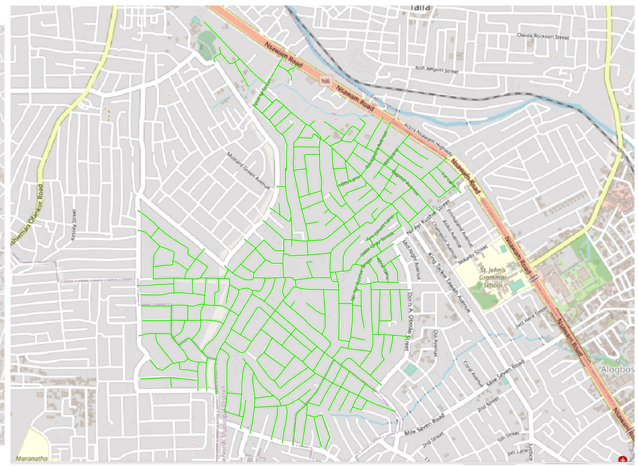
[19] A few cases, such as Harare under Mugabe (Potts 2011) or Luanda under the MPLA (Gastrow 2017), stand out in this literature precisely because they have such exceptionally high degrees of slum clearing. They are not the norm.

(a) Orientation order (O): 0.96

(b) Orientation order (O): 0.74



(c) Orientation order (O): 0.36



(d) Orientation order (O): 0.14

Figure 4: *Examples of neighborhoods as "t-communities" in Accra, Ghana*: following Grannis (1998, 2009), each shaded portion (green) of the street network is a separate neighborhood. The base is OpenStreetMap, with major roads (e.g., secondary, primary, highway, etc.) represented with thicker edges and/or different colors from residential streets.

ferent striations allow geologists to learn about conditions at the time a rock formed, pieces of a street network provide windows to when they were built. City streets can be "carbon dated," to extend the analogy, back-dating their origins through historical maps. I assemble an original dataset of city maps, combining archival paper maps from the pre-satellite era (before 1980) with satellite imagery from more recent decades. Many of the paper maps come from the unique collections at the Library of Congress. I geo-reference each map and merge it to the present-day street network, dating each street segment to an historical "band," defined as the years between the most recent

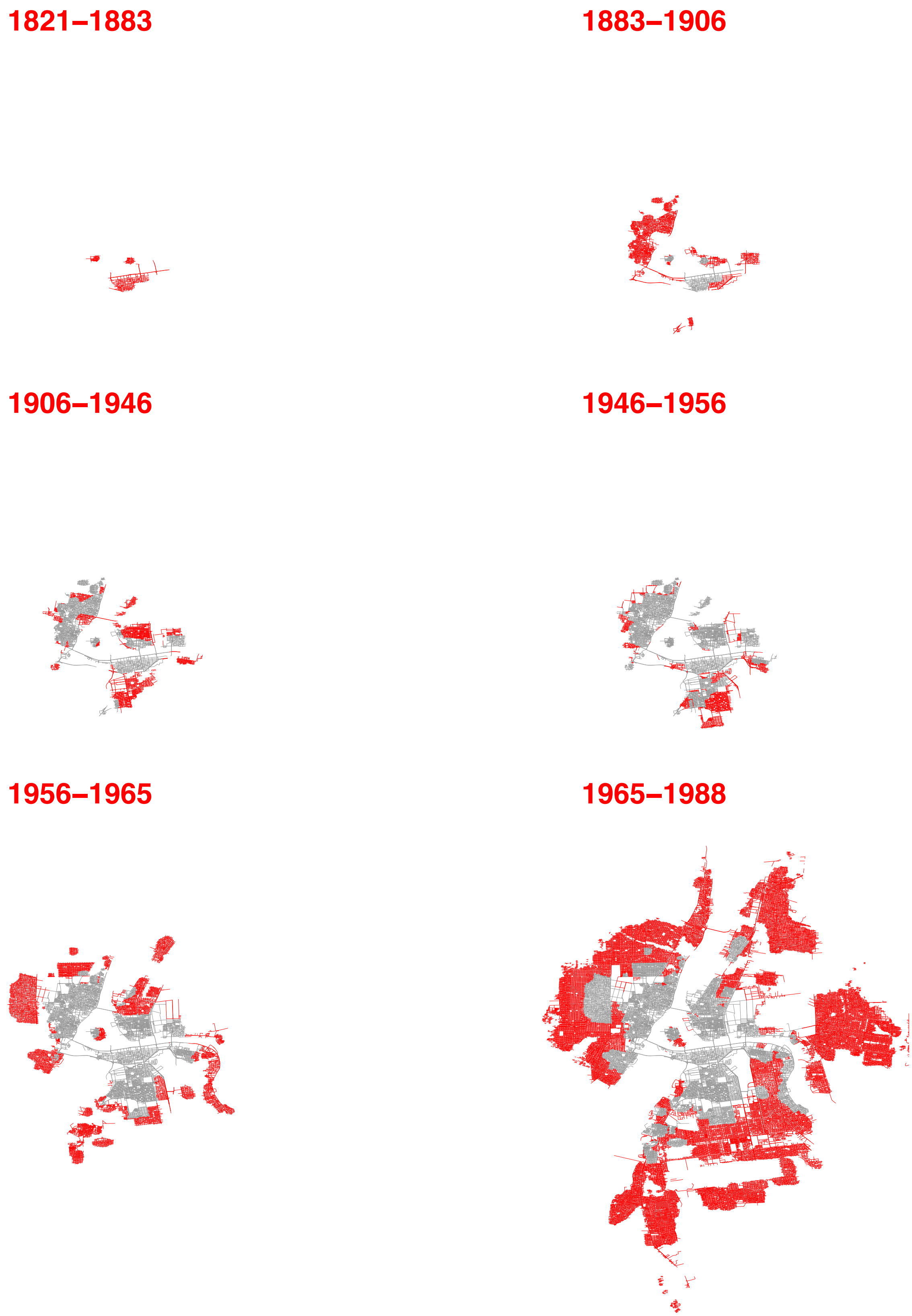


Figure 5: *Khartoum, example of historical "bands" (part 1)*: continued in Figure 6.

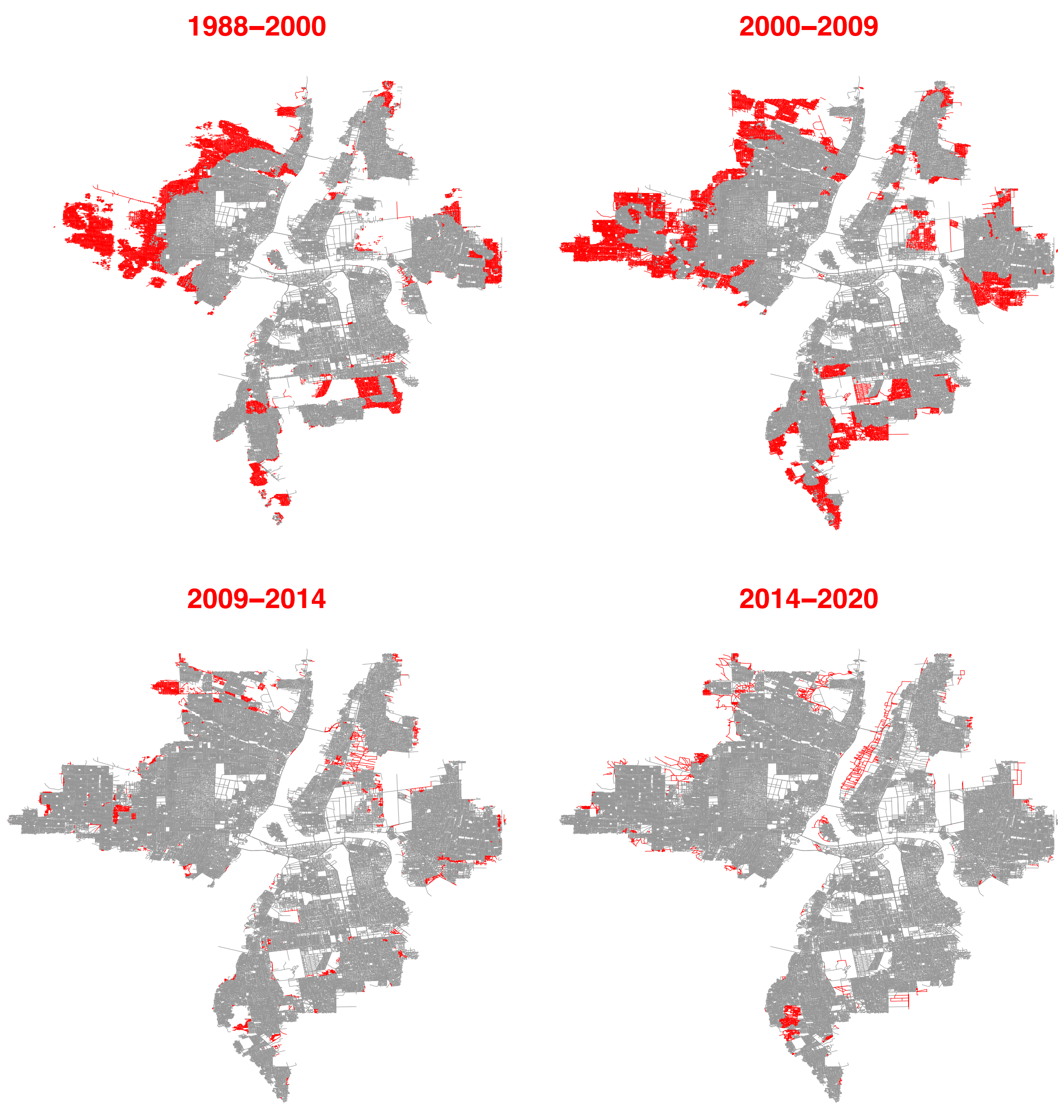


Figure 6: *Khartoum, example of historical "bands" (part 2)*: continued from Figure 5. Each panel indicates (in red) the streets identified as having been built between the listed years.

map in which that street's location appears as "greenfield" and the oldest map in which it appears as built area.[20] As an example, Figures 5 and 6 display Khartoum, Sudan from 1821-2020, marking off streets across 10 time bands.

This is a complex process. For most small African cities, few detailed historical maps exist, especially before the availability of satellite imagery. It is necessary to focus on a subset for which maps are more plausibly available. I concentrate on 36 cities (listed in Figure 3), selected by combining the 20 African cities in Angel et al.'s (2016) global random sample of 200 major cities, for which they provide detailed over time satellite data on urban footprints, with an additionally randomly selected 16 cities above a similar size cutoff, for which I then reproduce similar urban footprint data with Google Earth imagery. While not representative of *all* African cities, the resulting sample is representative of *large* African cities, defined here as those that either have populations above 200,000 or are one of the top-two by population in their country.[21] Compared to this reference set, the 36 selected cities do not have statistically significant differences in population density, topography, climate, colonial or precolonial history, or many other background features.[22] I attempt to locate historical maps or satellite images of each city at as close as possible to 10-year intervals, resulting in 227 maps/images from which streets can be dated to an average of 7.3 time bands per city.[23]

The dating is not without measurement error, but I cast doubt on two of the most challenging concerns. First, my approach cannot systematically observe redevelopment; I date when each location first appears as built. If a disordered, unplanned settlement is subsequently redeveloped

[20]Satellite images indicate built area at high resolution (Angel et al. 2016). To qualify for inclusion, paper maps must be highly detailed; many are multi-sheet documents, marking off individual streets and even structures. For any paper maps that do not mark off all streets (e.g., instead shading a particular area as built), my assumption (of path dependence) is that in locations in which the map indicates built area, streets today were lain out prior to that map.

[21]The sample size of 36 was determined by budget constraints. Locating and digitizing sufficiently high-resolution archival maps for each additional city is extremely time consuming.

[22]Descriptive statistics are on pg. SI4.

[23]Satellite images take precedence over paper maps whenever both are available. The bands for each city are on pg. SI5.

as ordered, I risk misattributing the legible present-day layout to the earlier regime that allowed the initial unplanned settlement. I assess this risk empirically by auditing a random sample of the most gridded (and thus planned) neighborhoods, tracing back specifically when the grid happened (pg. SI9). Consistent with path dependence, redevelopments are rare: layouts only change at all across time in 9% of these neighborhoods, and the current grid occurred under a different regime type than the original urban settlement in just 5%. Using simulations, I demonstrate that this degree of error is insufficient to explain my results (pg. SI9). Second, if autocracies are systematically more likely to omit disorderly neighborhoods from official maps, it could make them appear to have emerged later than in reality. But I also subset to the period after satellite images are available – when such omissions are impossible – and find similar results (pg. SI11).

3 Neighborhood-level analysis

I show that neighborhood-level grids are more likely to emerge under autocracy. I then raise and rule out a series of alternative explanations for variation in griddedness before considering which of the theorized mechanisms best explains the association between grids and autocracy in the subsequent section.

3.1 Regime type and griddedness

My main focus is the post-colonial period, subsetting to the 5,525 neighborhoods (73% of total) built after independence in each city.[24] My units are clustered (neighborhoods within cities within countries). I present three standard approaches for clustered data and find similar results across each. My approach is cross-sectional, controlling for time-invariant confounders by city and country, but remains descriptive and correlational because I cannot fully rule out time period-specific confounders, such as via a "two-way fixed effects" model. Because the time bands for dating

[24]For Liberia and Ethiopia, I code "post-colonial" as after 1950 to ensure comparisons within the same time frame as the other cities.

streets (Figures 5 and 6; pg. SI5) are unique to each city depending on which maps were available, it is not possible to create a standard time-series, cross-sectional panel dataset by city.[25]

I measure the average regime type at the time each neighborhood was built through V-Dem's "polyarchy" index, which is scaled from 0 (fully authoritarian) to 1 (fully democratic) (Coppedge et al. 2021).[26] I assign each street segment the mean polyarchy score for the years spanning the time band it was built. I then average over all streets in each neighborhood, assigning each neighborhood the average polyarchy score when it emerged, effectively weighted by the proportion of its streets built in each band.[27] Any time-varying covariates are similarly calculated as averages for each neighborhood based on when each street within it was built.

Panel (a) of Table 1 presents my primary specifications, with OLS models of the general form:

$$O_{icj} = \alpha_{cj} + \beta_1 Regime_{icj} + \beta_2 Average\_Date\_Built_{icj} + \theta \mathbf{X}_{icj} + \epsilon_{icj}$$

where O_{icj} is the orientation order of neighborhood i in city c and country j, $Regime_{icj}$ is either the average polyarchy score at the time neighborhood i was built or instead a summary indicator of that score, and α_{cj} are city fixed effects, holding fixed all time-invariant city- or national-level confounders, observed or unobserved, such as differences in climate, colonial history, or property rights regimes. Some models also include $Average\_Date\_Built_{icj}$, the average construction date (in years) of streets in neighborhood i to control for the possibility that neighborhoods become progressively less ordered over time. X_{icj} is a vector of neighborhood-level controls: topography – measured both as the median elevation of each neighborhood's streets (neighborhood altitude) and

[25] Irregular and unique periods for each city preclude estimating time period fixed effects. Transforming the data into regularized periods would introduce substantial measurement error because any periodicization scheme that does not involve a trivially small number of periods would cross-cut most cities' time bands, violating identification assumptions of a two-way fixed effects model and requiring arbitrary decisions about how to assign neighborhoods to particular fixed effects.

[26] The main results are also robust to using the binary codings of regime type from Geddes et al. (2014), which build on Przeworski et al. (2000) (pg. SI11). I prioritize V-Dem because it allows for more nuanced analyses.

[27] While many neighborhoods emerge all at once in a single time band, others developed gradually across multiple bands, with some streets dated as built before others.

the standard deviation of elevations (neighborhood hilliness) – and neighborhood size (number of nodes).[28] Hilliness is strongly correlated with lower orientation order across all models, consistent with some variation simply being due to the difficulty of fitting grids over more complex topographies.[29] Standard errors are clustered by country (j), as the treatment of interest – $Regime_{icj}$ – is ultimately assigned at the country level.[30]

The fixed effect models ("no pooling") are most conservative, ruling out the most potential confounding, so are the preferred specifications. However, for comparison, Panel (b) presents multi-level models with city random effects; intercepts vary by city, to control for baseline city-level differences, but data is otherwise pooled across cities (i.e., "partial pooling"), allowing the inclusion of specific city- and national-level covariates (Gelman and Hill 2007).[31] Finally, Panel (c) presents OLS models with no fixed or random effects; these models "fully pool" the data, while including the same set of neighborhood-, city-, and national-level controls as Panel (b) and still clustering standard errors by country (or alternatively, by city, with similar results).

In column 1, polyarchy predicts lower O across all three specifications: neighborhoods are more gridded when built under more autocratic regimes (lower polyarchy). Column 2 adds the average construction date of each neighborhood as a control. Because many African countries have followed similar time trends in regime type, average polyarchy when a neighborhood was a built and neighborhood age are strongly correlated (r=0.54 overall, and 0.83 on average within cities). Collinearity with this new control reduces the statistical significance for polyarchy in column 2,

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[28] Demographic data at the neighborhood level (e.g., ethnic or socio-economic composition) is unfortunately simply not available across cities, especially in the needed historical format.

[29] Combined with the fixed effects, which control for any city-level differences in climate, the topography controls demonstrate that terrain-based explanations, while important, are insufficient to explain all variation in griddedness.

[30] With only four countries having more than one city in the sample (Kenya, Liberia, Nigeria, South Africa), all results remain similar if errors are clustered by city (c).

[31] At the city level, these are hilliness (standard deviation of street elevations), if the city has been a national capital, whether the city is on a coast or international border, whether the city was a precolonial urban settlement, the city's annual rainfall, and soil quality. These latter two variables are from FAO (2012). At the national level, I control for colonial power(s) – dummies for Britain, France, and none, with other (e.g., Portugal, Spain) the omitted category – and whether the country was a settler colony.

Table 1: Neighborhood-level griddedness (O) and regime type, post-colonial period

Panel (a): no pooling: city fixed effects (within-city comparisons)

Outcome: Orientation order (O) by neighborhood	1	2	3	4	5
Average Polyarchy score (0-1)	-0.083^{*}	-0.069			
	(0.041)	(0.051)			
High autocracy (0,1)				0.032^{*}	0.030^{*}
				(0.013)	(0.014)
Average neighborhood age		0.000	-0.001		0.000
		(0.001)	(0.001)		(0.001)
Model type	OLS	OLS	OLS	OLS	OLS
City fixed effects	Y	Y	Y	Y	Y
City random effects	N	N	N	N	N
Neigh.-level controls	Y	Y	Y	Y	Y
City-level controls	–	–	–	–	–
Country-level controls	–	–	–	–	–
N	5525	5525	5525	5525	5525
adj. R^2	0.361	0.361	0.360	0.361	0.361

Panel (b): partial pooling: multi-level models (random effects)

Outcome: Orientation order (O) by neighborhood	1	2	3	4	5
Average Polyarchy score (0-1)	-0.087^{***}	-0.077^{*}			
	(0.023)	(0.034)			
High autocracy (0,1)				0.033^{***}	0.030^{**}
				(0.008)	(0.010)
Average neighborhood age		0.000	-0.001^{**}		0.000
		(0.000)	(0.000)		(0.000)
Model type	MLM	MLM	MLM	MLM	MLM
City fixed effects	N	N	N	N	N
City random effects	Y	Y	Y	Y	Y
Neigh.-level controls	Y	Y	Y	Y	Y
City-level controls	Y	Y	Y	Y	Y
Country-level controls	Y	Y	Y	Y	Y
N	5525	5525	5525	5525	5525

Panel (c): full pooling (no fixed or random effects)

Outcome: Orientation order (O) by neighborhood	1	2	3	4	5
Average Polyarchy score (0-1)	$-0.083^{\dagger}$	-0.072			
	(0.045)	(0.067)			
High autocracy (0,1)				0.036^{*}	0.036^{*}
				(0.015)	(0.017)
Average neighborhood age		0.000	-0.001		0.000
		(0.001)	(0.001)		(0.001)
Model type	OLS	OLS	OLS	OLS	OLS
City fixed effects	N	N	N	N	N
City random effects	N	N	N	N	N
Neigh.-level controls	Y	Y	Y	Y	Y
City-level controls	Y	Y	Y	Y	Y
Country-level controls	Y	Y	Y	Y	Y
N	5525	5525	5525	5525	5525
adj. R^2	0.327	0.327	0.326	0.327	0.327

† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. In panels (a) and (c), standard errors are clustered by country.

only remaining significant at conventional levels in Panel (b). But the coefficients on polyarchy remain similarly-sized as column 1, while the coefficient on age is effectively 0, with p-values in each panel above 0.78. Moreover, when included on its own in column 3, age is not significantly associated with O in two of the three specifications, demonstrating little robust evidence for a time trend in neighborhood legibility. Taken together, columns 1-3 are more consistent with regime type being the more important predictor.

Columns 4-5 also explore the possibility that regime type has a non-linear relationship with griddedness. I find that the most autocratic regimes in the sample, compared to all others, drive the greatest variation in O. The simplest way to show this is by converting polyarchy to a binary variable split at its median value (0.23), with neighborhoods built in the most autocratic periods in the sample (average polyarchy ≤ 0.23) equal to 1.[32] There are few years of full democracy in most African countries in this data (e.g., above 0.5); instead, most variation is among shades of authoritarianism, such as between military or personalistic dictatorships with small selectorates – and very low polyarchy – and competitive authoritarian regimes, which while still placing clear restrictions on opposition, face elections and are responsive to a wider set of citizens – and have more middling values of polyarchy.[33]

Across panels (a)-(c) of Table 1, column 4 shows a clear correlation between below-median autocracy and griddedness. The binary version survives controlling for neighborhood age in column 5, while age itself is uncorrelated with O across each estimation approach. Overall, Table 1 suggests a clear correlation between regime type – especially very autocratic regimes – and the production of more legible, gridded street layouts.

[32] I find a similar non-linear relationship via more complex GAM regressions; order (O) peaks among neighborhoods with below median average polyarchy and then declines sharply after the median (pg. SI11).

[33] I list periods classified as "high autocracies" on pg. SI14.

3.2 Alternative explanations

I consider two broad categories of alternative explanations for Table 1. That regime type predicts urban legibility at all is puzzling if producing order is as costly as Scott (1998) or Mumford (1961) suggest; this data is from states mostly near the bottom of the global distribution of state capacity (Hanson and Sigman 2021). Moreover, Africanist scholarship argues that structural adjustment reforms – widespread in the region in the 1980s and 1990s – gutted planning capacity, sparking more unplanned development (Yeboah 2000, UN-Habitat 2014, Fox and Goodfellow 2016). If state capacity serves as such a clear constraint, any relationship with regime type should at least be concentrated among relatively higher capacity states within my sample. Rather than a general relationship, is Table 1 driven by a few more capable cases?

Table 2: Neighborhood-level griddedness (O) and state capacity, post-colonial period

Outcome: Orientation order (O) by neighborhood	1	2	3	4	5	6	7	8
High autocracy (0,1)	0.044***	0.043***	0.030†	0.021	0.033*	0.028†	0.026*	0.058*
	(0.012)	(0.009)	(0.017)	(0.032)	(0.015)	(0.017)	(0.013)	(0.029)
Average state capacity (Hanson and Sigman 2021)	0.027	0.034						
	(0.026)	(0.025)						
Avg. state capacity * High autocracy		−0.015						
		(0.016)						
Average GDP per capita			−0.002	−0.002				
			(0.005)	(0.005)				
Avg. GDP * High autocracy				0.002				
				(0.005)				
Average ΔGDP per capita					0.001	−0.003		
					(0.003)	(0.004)		
Avg. ΔGDP * High autocracy						0.009		
						(0.006)		
% Post-IMF structural adjustment							−0.015	0.008
							(0.019)	(0.029)
% Post-IMF * High autocracy								−0.054
								(0.048)
Model type	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
City fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
City random effects	N	N	N	N	N	N	N	N
Neigh.-level controls	Y	Y	Y	Y	Y	Y	Y	Y
City-level controls	–	–	–	–	–	–	–	–
Country-level controls	–	–	–	–	–	–	–	–
N	5525	5525	5525	5525	5525	5525	5525	5525
adj. R^2	0.362	0.362	0.361	0.361	0.361	0.362	0.362	0.362

† significant at $p < .10$; $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$. Robust standard errors clustered at the country level. GDP and ΔGDP scaled in \$1000s for readability.

Extending panel (a) of Table 1, I find no evidence in Table 2 that capacity limits the ability of Africa's autocracies to oversee production of more legible neighborhoods.[34] First, I include Hanson and Sigman's (2021) yearly measure of latent state capacity in columns 1 and 2 of Table 2. Autocracy still strongly predicts griddedness when controlling for state capacity (column 1) and there is no interaction (column 2). Second, GDP also proxies state capacity (e.g., Fearon and Laitin 2003) and helps measure a state's budget constraint. But columns 3 and 4 similarly show that autocracy still predicts griddedness even controlling for GDP at the time each neighborhood was built. Autocracy and GDP again do not interact. Third, columns 5-6 of Table 2 instead examine changes in GDP per capita across the time bands, testing whether states are better able to produce legibility in economic boom times when they are less resource constrained. I again find null results.[35] Fourth, in columns 7-8, I date the onset of IMF-backed structural adjustment (if any) in each country (Reinsberg et al. 2019). Contrary to conventional wisdom, neighborhoods built after structural adjustment are not less (or more) orderly than those built before. The relationship between autocracy and griddedness persists and does not interact with structural adjustment. Across Table 2, state capacity and resource access do not appear to be constraints on the production of legible streets, even among some of the world's ostensibly least capable states.

A separate category of alternative explanations focuses on how "planning cultures," which could correlate with and confound regime type, encode different aesthetic principles. Baruah et al. (2021) show that French versus British colonial states built downtown cores with different layouts. Colonial planning cultures most directly affect neighborhoods built in the colonial period, outside the scope of Table 1. But they could affect post-colonial designs if templates introduced during colonialism became internalized (Baruah et al. 2021). Moreover, before colonization, some societies already used grids, while others did not (Bigon and Hart 2018). If design norms persist, present-day variation could be rooted in different experiences of precolonial urbanization.

[34] Separately, I also validate that this relationship is not driven by any particular outlier using a "jack knife" analysis that sequentially drops each city and finds the same overall result.

[35] The result for "high autocracy" is also robust to controlling for how many new streets in total emerged during the historical period each neighborhood was built, a measure of the rapidity of urban growth.

But tests in the SI (pg. SI16) provide little evidence these legacies matter for post-colonial urbanization. The results in Table 1 also already control for colonial and pre-colonial history. I also rule out a separate channel for colonial legacies via property rights regimes. Boone (2014) shows that whether an African country was a settler colony strongly predicts the region's main variation in *de jure* land institutions – whether countries have "statist" (state-dominated) or neo-customary property rules[36] – which could affect land use practices that also influence design. But panels (b) and (c) of Table 1 already control for whether each city is in a former settler colony. I find no differences in legibility across former settler vs. non-settler colonies (pg. SI16).

Post-colonial planning cultures could also explain variation in griddedness. Many major urban construction projects in Africa occur with input from external advisers. In the Cold War, states more linked to the USSR may have adopted designs from Soviet or Eastern-bloc planners (Stanek 2020), while those closer to the West may have instead used paradigms more prevalent there. Indeed, Scott (1998) observes that orderly designs were particularly in vogue among followers of the architectural paradigm of "modernism" ("high modernism") prominent in the mid-20th century; modernist principles were often implemented at grandest scale in Soviet-aligned countries (e.g., de Graaf 2017, 37-39). In more recent years, cities exposed to greater Chinese investment and aid may also be more likely to import Chinese planning ideas. Drawing on datasets such as Casey (2020), I employ several measures of African states' links to different external backers (e.g., Soviet, Chinese, Western) and find no differences in griddedness of neighborhoods (pg. SI16). Consistent with broader finding of no time trend in Table 1, I also find no evidence that Table 1 is specific to the historical period (1945-1975) modernism was most in fashion.

[36]Few African states have had sustained experience with pure private land markets (Boone 2014).

4 Mechanisms: why do autocracies build gridded streets?

Why do autocracies produce more gridded neighborhoods? I confirm that Scott's (1998) account of urban order as an explicit tool for coercive control of protest finds little support in the African data, implying that a different logic must explain these cases. Instead, consistent with the alternative mechanism introduced above, I show that gridded layouts are a side effect of autocratic regimes' attempts to coopt support through state housing selectively targeted at core urban constituencies.

4.1 Legibility as protest proofing?

Haussmann's redesign of Paris is a perfect example for Scott's (1998, 61) account – an autocracy implementing an ordered street layout to facilitate movement of security forces against protesters. Three testable implications can be drawn from this example. First, Paris was refashioned in response to the 1848 uprisings, suggesting that autocrats who face the most serious risks of urban revolt, such as in the aftermath of major contentious episodes, should be most willing to undertake costly efforts to increase a city's legibility. Second, Haussmann focused on central Paris, while illegible neighborhoods were left be on the city's periphery (Scott 1998, 63; Gould 1995). Expanding on Scott's logic, Beissinger (2022) explains that the threat of protest declines in distance from state power centers, with protests most challenging when concentrated in central public spaces – such as Cairo's Tahrir or Kyiv's Maidan – near core state institutions.[37] Third, bundled into Haussmann's efforts was an attempt to better link the street networks of residential neighborhoods to wider boulevards that troops could more easily navigate to stamp out unrest.

I do not find evidence consistent with any of these implications. First, combining data on major urban protests and uprisings from Chenoweth and Shay (2019) and Thomson et al. (2022), as well as data on attempted coups aggregated in Lachapelle (2020), I code whether each street segment

[37] Collier (1976) similarly documents how autocrats in mid-20th century Peru were concerned about the threat from slums in downtown Lima, but happy to tolerate illegible shantytowns at the city's outskirts.

was built in a year a major contentious event occurred in that city, or instead was built within 5 years after such an event.[38] Unlike Paris, however, neighborhoods built during or just after periods of contention are no more legible than those built in periods of calm, and the autocracy-griddedness relationship does not change based on the recency of contention (pg. SI21).[39]

Second, I geolocate the main center of state power for each year in each city and calculate the distance from each street at the time it was built. For capitals, this is distance to the presidential palace; in non-capitals, the provincial headquarters, if any, or city hall. Contrary to the suggestion that the imperative for legibility should decline as one moves into the urban periphery (Collier 1976, Beissinger 2022), autocracy predicts greater griddedness just as strongly in neighborhoods far in a city's outskirts as next to the palace (pg. SI21). Moreover, the results in this section also hold subset to capital cities, where fears of protest are most acute (pg. SI21).

Third, I calculate the distance of each street to a major thoroughfare, leveraging OSM's demarcation of primary and secondary roads from residential streets. I calculate how easily reached each neighborhood is from major roads: the distance from each street segment, traveling through the street network in existence as of when that segment was built, to the nearest existing major road.[40] Unlike Paris, I find no evidence that neighborhoods built in more autocratic periods are better linked to navigable boulevards that security forces could more easily use (pg. SI21).

4.2 Byproducts of state housing provision

Instead of facilitating coercion, grids appear instead to emerge as a byproduct of housing construction aimed at coopting subsets of the urban population, with grids a default, low-cost layout for many state developments. This would explain the relationship between autocracy and griddedness

[38] This data records large-scale protests (violent or nonviolent), urban-based insurgencies or war, and, for capital cities, (attempted) regime changes via coups. See pg. SI21 for inclusion criteria.

[39] Results are similarly null for other year cutoffs (e.g. within 10 years).

[40] OSM does not measure street width. I instead proxy for width with road type, assuming that highways and main thoroughfares are wider than residential streets.

if Africa's autocracies invested more extensively in building housing than democracies – and thus intervened more systematically on urban space.

No "off-the-shelf" data on state housing exists, however: official statistics are rarely available, especially in consistent format. But there are often sizable qualitative literatures on urban governance and housing policy in these cities that detail when states built housing, including at what general scale, how, and to whose benefit. I treat this secondary literature as data, using Google Scholar to identify any articles or books that make an even passing reference to state housing construction in 22 of the 36 sampled cities.[41] I focus on the subset of cities in which there is enough internal variation in regime type needed to disaggregate the fixed effects from Table 1 and estimate separate within-city regressions (pg. SI22). This subset is sufficient to allow me to interact a measure of state housing with the high autocracy indicator, as data from cities without this variation did not inform the coefficient on high autocracy in the fixed effects models to begin with. I locate sufficient materials in 20 cities, dropping Lubumbashi and Oyo.

I use two criteria to code a city-year as having state housing provision. First, secondary sources must include that year in a time period when state-led housing developments of at least 500 units total were being built.[42] This cutoff is arbitrary, but allows me to focus on construction corresponding to an area large enough to leave a visible imprint on city streets.[43] Second, I include developments described either as direct construction or "sites-and-services." In "sites-and-services" schemes – cheaper than direct construction and more common among lower capacity states in my sample (pg. SI24) – states lay out well-demarcated plots, build roads around them, extend some basic services (e.g., electricity), and sometimes also providing a starter structure, but leave recipients to finish homes on their own (e.g., Fox and Goodfellow 2016). Both approaches involve laying out

[41] I include French language sources.

[42] Most projects take more than one year to build and most states build more than one project a time. I include any years a source indicates a housing program of this approximate size was active.

[43] Most construction described in these sources far exceeds this threshold; small tweaks to the cutoff (e.g., 400 vs. 600) would not affect almost all codings.

new streets. I instead exclude pure private-sector incentive schemes (e.g., reducing red tape for, or states buying stakes in, private developers) and *in-situ* "slum upgrading." In the former, street layouts are not shaped by state design choices or budget constraints, but private developers'. In the latter, by definition, new (or renovated) housing is built where slums already are – on land my data would already have coded as built area – with often limited change to street networks.[44]

These secondary sources do not allow me to quantify the exact number of units per year, the overall proportion of a city's housing that is state-built, or to consistently identify the names of specific state-built neighborhoods. Instead, I simply observe whether at least *some* neighborhoods under construction in a given city-year were designed top-down by the state. Even if state housing represents a minority of total units, the average griddedness of neighborhoods built at that time should still observably shift on the margins if state-built developments are much more gridded than a city's *status quo*, unplanned private construction.

Consistent with the argument above, state housing provision has been a very common distributive strategy in urban areas in Africa's autocracies, even in very poor states and at their most autocratic moments: 75% of these 20 cities had state housing provision during a period they were coded as a high autocracy (polyarchy ≤ 0.23); housing programs were active, on average, in 41% of the total city-years under high autocracy. Civil servants, employees of parastatal companies, or other middle to high income formal sector workers were identified as the primary recipients of 71% of projects in periods of high autocracy, consistent with the claim above that these efforts typically did not target the urban population in general, but instead focused on delivering patronage to relatively elite strata most politically important to autocratic regimes.

By contrast, state provision has been less common in democratic periods. Only 29% of years with polyarchy scores above 0.5, a standard cutoff for full democracies (Coppedge et al. 2021), had new state housing. But this is inflated by an outlier – South Africa, which has three cities in

[44] I still include any cases in which slum-upgrading is described as *not* in-situ – relocating slum dwellers elsewhere.

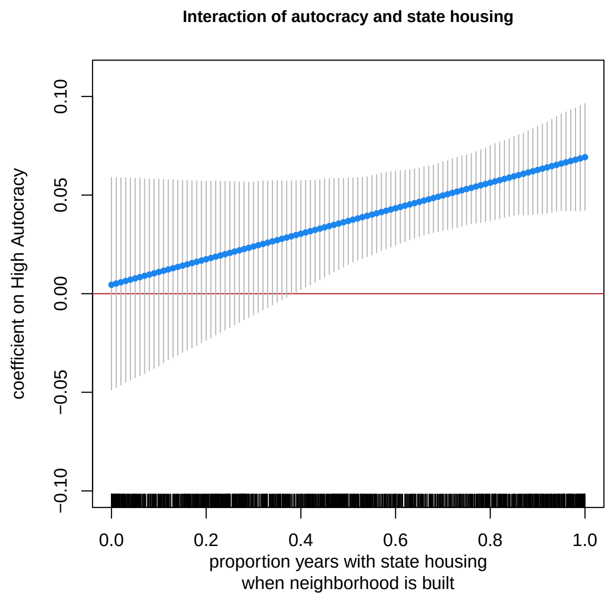

Figure 7: *Interaction of high autocracy and state housing provision*: coefficient estimate for high autocracy's impact on order (O) (y-axis) simulated across the range of the proportion of years when each neighborhood was built that had active state housing construction (x-axis), with 95% confidence intervals. The underlying model repeats column 5 of panel (a) of Table 1, but adds the interaction with state housing.

my sample (Johannesburg, Cape Town, and Port Elizabeth). After apartheid, South Africa began a massive pro-poor housing effort far beyond the other cities, building at times over 100,000 units per year over 25 years. Without South Africa, only 9% of city-years with polyarchy above 0.5 have state provision, compared to 34% of city-years with polyarchy below 0.5.[45]

I include a measure of housing provision as an additional predictor in regression models similar to Table 1 and show that the time periods when grids emerged are the same time periods when states built housing. I operationalize this as the proportion of years in which state housing provision was occurring averaged over the years when each neighborhood's streets were built. In the fixed effect model from column 5 of Panel (a) of Table 1, this new variable predicts griddedness, with p=0.08,

[45]Consistent with its status as an outlier, dropping South Africa makes the main result in Table 1 above larger.

with neighborhoods built at a time the state was fully active in housing construction scoring 4.1 p.p. (95% CI: -0.5, 8.6) higher on orientation order (O) than neighborhoods built when housing provision was inactive. Most importantly, the proportion of years with state housing provision interacts with high autocracy, as visualized in Figure 7 (p=0.07 on the interaction). Consistent with housing being the key mechanism for my main result, high autocracy *only* predicts greater griddedness in periods with sustained state housing provision.

A confirmatory "back-of-the-envelope" test of this mechanism can also come from adapting the approach to theory-testing in "small-N" nested case studies developed by Lieberman (2005) to this "medium-N" setting, comparing the cities within which there is a positive sign on the relationship between high autocracy and griddedness (O), consistent with the overall result, to the smaller set of cities that instead internally deviate from the main pattern and have a negative relationship. If my theory of grids' origins is correct, the city-level observations that fit the overall pattern in the full "large-N" data should be those in which there is clearest evidence of the theory operating.

This is what I find: among the cities with positive autocracy-griddedndess relationships when estimating column 4 of panel (a) of Table 1 separately by city, the average polyarchy score in years with state housing provision is 7.3 p.p. lower than in years without it. In these cases – the observations responsible for the overall positive result – the state built more housing in more autocratic periods and more gridded streets emerged in those periods. By contrast, in the smaller set of deviant cases in which there is instead a negative autocracy-griddedness relationship, the relationship between autocracy and housing also flips; the average polyarchy score in years with housing is instead 8.1 p.p. *higher* than in years without.[46]

How could autocrats in low capacity states build so much? Two common answers emerged from the cases. First, changing urban form is not as expense as Scott's (1998) anecdote of Paris implies. Much construction has been greenfield, without displacement of existing residents. For

[46]This difference remains similar when focusing on column 5 of panel (a) of Table 1 instead.

example, Nkrumah's autocratic regime in Ghana built thousands of gridded units as part of the new planned city at Tema, at the outskirts of Accra, but Tema was created on rural farmland, with only a few villages needing to be relocated (Arku 2009*a*). Moreover, many projects were sites-and-services schemes in which costs are kept low, but recipients still benefit from access to state lands. For example, in Kinshasa under Mobutu in the 1970s, Zaire's deeply dysfunctional state still built three greenfield neighborhoods at the same time as municipal governments executed an even larger *de facto* sites-and-services scheme: "miles on miles of residential grids were... laid out for workers' families," after which residents could build on their own (Sacks 2023, 156; Sangu 2021).

Second, housing is such a central political imperative to some autocrats that they concentrate limited resources in the particular agencies focused on housing, even as other governance tasks remain neglected. Nkrumah's regime placed housing at the "core of its social policies," devoting "tremendous effort" (Arku 2009*b*, 262) by creating heavily-subsidized state firms that continued operating throughout the autocratic 1970s (Arku 2009*a*, 294; Arku 2009*b*, 264; Paller 2015, 33). Although Ghana's state capacity in the 1970s is typically described as bottoming out amidst protracted economic collapse, the state was still able to deliver in specific domains, like housing, in which it concentrated effort (Chazan 1982). Similarly, the MPLA's construction boom in Luanda in the mid-2000s occurred against the backdrop of an official urban planning bureaucracy hollowed out by decades of neglect (Gastrow 2020). While keeping the formal state purposefully weak (Soares de Oliveira 2015), the MPLA funneled oil revenues into a "parallel state" controlled by the President. These parastatal "pockets of effectiveness" (McDonnell 2020) built vast, gridded housing estates meant "to appease and co-opt a rising urban middle class" (Pitcher 2017, 377) and buy "loyalty and support of the MPLA's historic base," including "veterans and public servants" (Croese and Pitcher 2019, 405).

Why do more democratic regimes build less? Many cases suggest a similar answer: when facing a far larger selectorate in electoral periods, scaling up housing efforts that had previously targeted narrower subsets – such as civil servants – becomes prohibitively costly. It is not a coincidence that virtually the only democracy in the sample to attempt sustained, large-scale direct provision targeted at its median urban voter – the urban poor – is South Africa, which was *by far* the highest capacity state in my sample when its port-apartheid housing initiative began (Lieberman 2003).

For most electoral regimes, standing aside, forbearing (Holland 2017), and allowing unplanned settlements to expand privately becomes a more promising means to address mass demand for housing (Fox and Goodfellow 2016), while also creating politically-valuable dependency among residents who can be threatened with selective enforcement. In Accra, elected politicians put pressure on bureaucrats to under-enforce planning rules in the face of a housing deficit too large for the state to realistically close in the near term (Deuskar 2022). From interviews with these bureaucrats, Cobbinah and Darkwah (2017, 1230) summarize the city's current planning ethos: "A well planned city does not vote but people who live in unapproved neighbourhoods do." In unplanned neighborhoods, tenure security has become a patronage good mediated through partisan brokers, allowing the contingent provision of housing to operate at a larger scale than possible through direct construction (Paller 2015, Paller 2019). Similarly, in Abuja, the state retreated from formal construction from the mid-1990s, before Nigeria's transition to democracy. But elected politicians have remained highly active since informally distributing land for housing through clientelist transactions; this includes selectively utilizing a public-private partnership that grants subsidized land to developers, with arbitrary, unofficial building approvals combined with threats of selective expropriation serving as tools to extract rents and votes (Umoh 2012, Abubakar 2014).

5 Conclusion

Using street network data, historical maps, and satellite imagery, I back-date the construction of individual city streets across a sample of large African cities and show how the design of built environments structuring urban politics is shaped by the political imperatives of state leaders. These analyses provide empirical confirmation for Scott's (1998) classic observation that autocrats produce legible, gridded cities, yet push beyond Scott (1998) in theorizing a broader range of conditions under which regime strategies of political control manifest in more ordered urban designs. While expansive city-building schemes explicitly imposing legible urban plans may primarily be the function of high capacity states – a claim future scholarship can better validate in a different set of empirical cases – I show that even much lower capacity states are capable of reshaping urban built environments as a downstream consequence of their targeted strategies of cooptation.

Studying the explicit design of built environments also suggests promising empirical opportunities for future scholars of urban politics. To those in the growing field of historical political economy (Charnysh et al. 2023), the path dependent nature of streets in particular make them an underexplored, new source of data through which to observe the legacies of path state efforts to reshape society. Moreover, if Scott's (1998) broader claims about legibility are right, the outcome in this paper – griddedness – should have its own important political effects, altering how grassroots collective action, state repression, and other forms of state-society interaction unfold across urban space. Future research can valuably pivot to exploring similar features of the built environment as explanatory variables.

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Supporting Information (Online Appendix) for
"Explaining Urban Order"

Page numbers for corresponding references in the main text are in parentheses.

Contents

1 City-level regressions (pg. 14)

Table SI.1 shows predictors of orientation order (O) using the full set of Sub-Saharan African cities. The unit of analysis is now the city, not the neighborhood. Because this aggregated analysis cannot disentangle when each street was built, it cannot explore how conditions at the time a specific area emerged explain its layout. However, Table SI.1 confirms the claim in the main text that topography matters for griddedness. It also shows that there are not clear differences across cities colonized by different powers.

Column 1 includes country fixed effects, looking at variation across cities within countries against a series of city-level predictors. Consistent with topographical explanations for some variation in orientation order, hillier cities and cities with wetter (e.g., more tropical) climates are significantly less gridded. By contrast, cities with higher soil quality, more suitable for agriculture, are significantly more gridded. A history of precolonial urbanization is associated with less order overall and cities that are currently national or provincial capitals are more disordered.

To include country-level predictors as well, Column 2 is instead a multi-level model with varying intercepts (random effects) by country. In addition to similar results as column 1 for city-level predictors, it shows that settler colonies have cities that are on average less gridded. I also find no difference in the overall level of griddedness across cities colonized by different European powers (French colony is the omitted category).

2 Validating t-communities as neighborhoods: Accra data (pg. 18, fn. 17)

I define neighborhoods as "t-communities" (Grannis 1998). Do "t-communities" reasonably approximate neighborhoods that residents would recognize?

For a companion paper, I collect individual-level survey data for representative samples of 42 residents from each of 20 t-communities in Greater Accra, Ghana ($n = 830$). Building on the approach in Wong et al. (2012), which asks respondents in the US to draw their neighborhood boundaries as they perceive them, each respondent was asked to identify boundaries of what they consider their neighborhood. Respondents were asked to identify landmarks, by name, in each of four directions from their home at which they believe their neighborhood ends and the next neighborhood begins.[1] Research assistants then geolocated the landmarks, constructing 4-sided polygons of the approximate perceived neighborhood of each respondent.[2] These polygons are then projected on top the t-communities derived from the street network data.

[1]The question wording was: *"We want to better understand the boundaries of this neighborhood. Imagine you came out of your house onto the street and [TURNED RIGHT / TURNED LEFT / WENT BACKWARDS / WENT FORWARDS] and kept walking in that direction. At what point would you say you had left your neighborhood and entered a new neighborhood? Can you identify a particular street or landmark that is the boundary between them?"* Each respondent was asked the question 4 times, for each direction.

[2]58 respondents (7%) are dropped because we were unable to locate sufficient landmarks to construct a polygon of boundaries.

Table SI.1: City-level predictors of orientation order (O)

	1	2
Model type:	OLS	MLM
Population density (10K / sq km)	0.004^{*}	0.005^{**}
	(0.002)	(0.002)
City population (total)	-0.000	0.000
	(0.000)	(0.000)
Median street elevation	-0.000	0.000
	(0.000)	(0.000)
Stand. dev. of street elevations (hilliness)	-0.002^{***}	-0.002^{***}
	(0.000)	(0.000)
Annual rainfall (FAO 2012)	-0.000^{***}	0.000^{***}
	(0.000)	(0.000)
Soil suitability (FAO 2012)	0.000^{***}	0.000^{***}
	(0.000)	(0.000)
Coastal city – ocean (0,1)	0.006	0.001
	(0.020)	(0.020)
International border city (0,1)	0.009	0.007
	(0.014)	(0.014)
Major precolonial city (0,1)	-0.034^{*}	$-0.032^{\dagger}$
	(0.017)	(0.017)
National capital (0,1)	-0.073^{*}	-0.081^{**}
	(0.030)	(0.029)
Provincial (1st order admin) capital (0,1)	-0.047^{***}	-0.046^{***}
	(0.012)	(0.012)
Settler colony (0,1)		-0.091^{*}
		(0.043)
Colonial power: Britain (0,1)		-0.045
		(0.035)
Colonial power: Other (e.g., Portugal, Spain) (0,1)		-0.013
		(0.046)
Colonial power: None (0,1)		-0.005
		(0.071)
Country FEs	Y	N
Country REs	N	Y
N	1001	1001
adj. R^2	0.465	$--$

† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. MLM are multi-level models with clustered intercepts (random effects) by country (Gelman and Hill 2007). French colony is the omitted category in column 2.

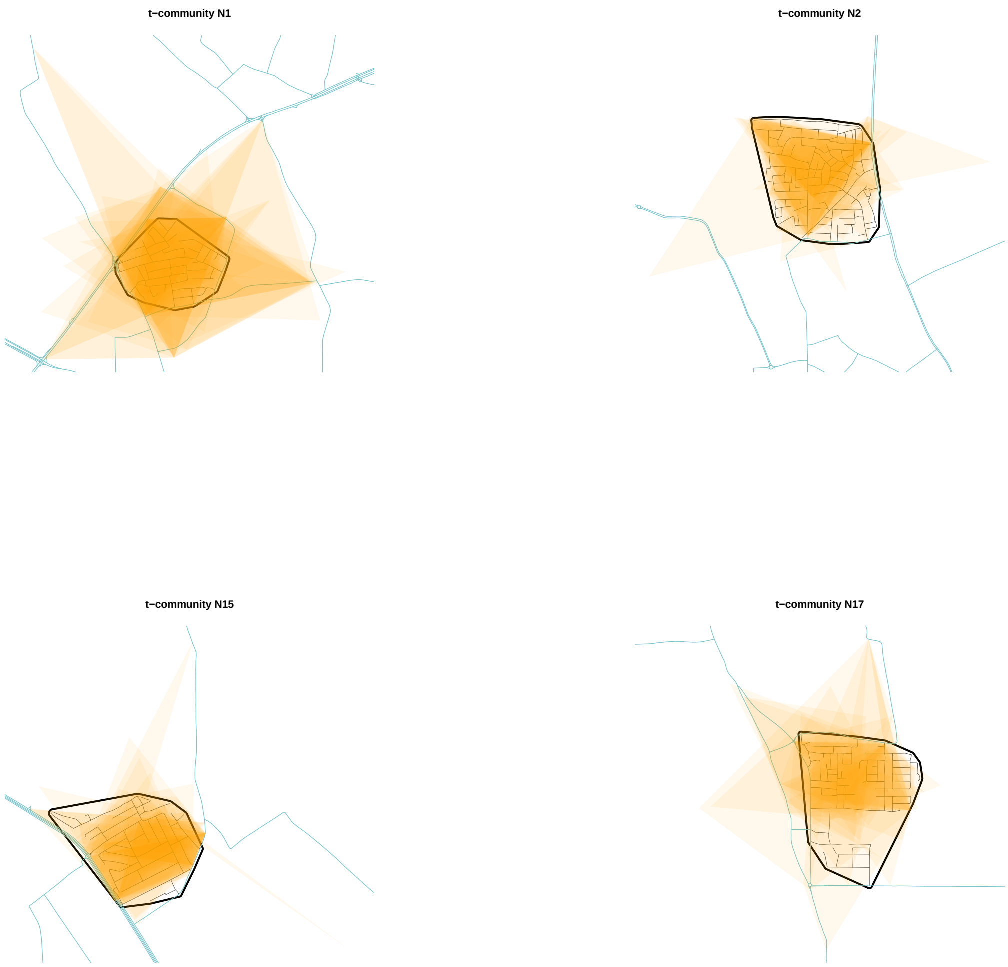


Figure SI.1: *Examples of overlap between perceived neighborhood boundaries and t-community boundaries*: 4 of the 20 t-communities in the Accra survey data. Darker orange shading indicates overlap in respondents' reported neighborhood boundaries. The thick black lines are the outer bounding polygon of the t-community. The individual streets are the light gray lines. The teal lines are major roads in the surrounding area.

Figure SI.1 gives examples from four of the t-communties in the sample.[3] Each polygon created by respondents' self-reported boundaries is represented in light orange. Darker orange shading indicates greater overlap/agreement among respondents that a location is part of their neighborhood. The grey lines indicate the individual streets contained within that t-community. The black lines are a bounding polygon showing the outer boundaries of the t-community. The teal lines indicate major roads in the vicinity.

[3]Figures for all 20 t-communities are available on request but not shown due to the journal's page limits.

Visually, Figure SI.1 makes two things clear. First, people living in the same place often disagree about exact neighborhood boundaries – confirming the central insight of Wong et al. (2012) and demonstrating why defining neighborhood boundaries is such a complex task. Second, however, Figure SI.1 also shows that t-communities provide a decent, albeit imperfect, approximation of these boundaries, on average. This can be confirmed quantitatively: on average, 70% of the area included in respondents' polygons (orange) was contained within the bounding polygon (black lines) of the t-community in which they live, suggesting a strong degree of overlap between neighborhoods derived from the street network data and the perceived neighborhoods experienced by residents. Absent a better way of consistently defining neighborhoods across a large sample of cities – including because granular survey data of this type is not feasible to collect at scale – t-communities provide a useful approximation.

3 Representativeness of city sample (pg. 22, fn. 22)

Table SI.2: Selected cities vs. population of large African cities (t-tests)

Variable:	Population mean	Sample mean	Difference	p-value
Population (in 1000s)	759.2	2118.9	1359.7	0.003
Population density (per sq km)	36001.9	26578.7	-9423.2	0.161
Hilliness (elevation std. dev.; meters)	22.2	35.2	13.1	0.015
Elevation (median; meters)	622.7	628.7	6.0	0.96
Precolonial city (0,1)	0.26	0.24	-0.02	0.83
British colony (0,1)	0.53	0.57	0.04	0.64
French colony (0,1)	0.20	0.14	-0.06	0.32
Settler colony (0,1)	0.21	0.30	0.09	0.29
International border (0,1)	0.15	0.22	0.07	0.33
Avg. annual rainfall (mm)	1162.8	1137.5	-25.3	0.81
Soil quality (FAO index)	5751.0	5573.9	-177.11	0.59
Coastal city (0,1)	0.16	0.30	0.14	0.09
Orientation order (O)	0.15	0.11	-0.04	0.07
N	321	37	–	–

The sample N here is 37 because Abuja, Nigeria enters Boeing's (2021) data as two spatially discontinuous observations. Abuja is merged into a single observation in all other analyses.

The city sample was selected in two stages. First, I draw on existing data on over time changes in built extents from Angel et al. (2016). Twenty of these cities are in Sub-Saharan Africa and are included in my sample. Next, to increase the sample size, I supplement with 16 additional cities, drawn randomly among the remaining Sub-Saharan African cities that are at least as large as the smallest such city in the Angel et al. (2016) sample and/or are a top-2 city by population in their country. This restriction subsets to prominent African cities, meant to restrict the sampling frame to those sufficiently high profile that historical maps are plausibly available. For these additional 16 cities, I reproduce similar data as in Angel et al. (2016), at similar time intervals, using Google Earth imagery. For all 36, I locate archival historical maps from before the satellite era.

Because a size cutoff is purposefully employed in the sampling, the selected 36 cities are not representative of *all* African cities. However, t-tests in Table SI.2 show that the sample is representative of large African cities. The only differences significant at the $p<0.05$ level are that the selected cities are more populous – the set includes Lagos, an outlier in population (4.7m more people than next most populous city) in Boeing's (2021) data – and slightly hillier than the full population. At the $p<0.1$ level they are also marginally more gridded and more likely on a coast.

4 Historical bands by city (pg. 22, fn. 23)

Table SI.3 lists the historical bands between which I can date street segments in each city in my sample. It also lists the type of data source for each map/image used to define the bands. There are three data types: "paper" – paper, archival maps, many of them located at the Library of Congress; "GE" – satellite imagery from Google Earth; "Angel" – urban footprint data based on satellite imagery from Angel et al. (2016). The final column lists my best estimate of the historical founding date of the modern version of each city, which becomes the starting date for the first historical band defined by the first available map/image.

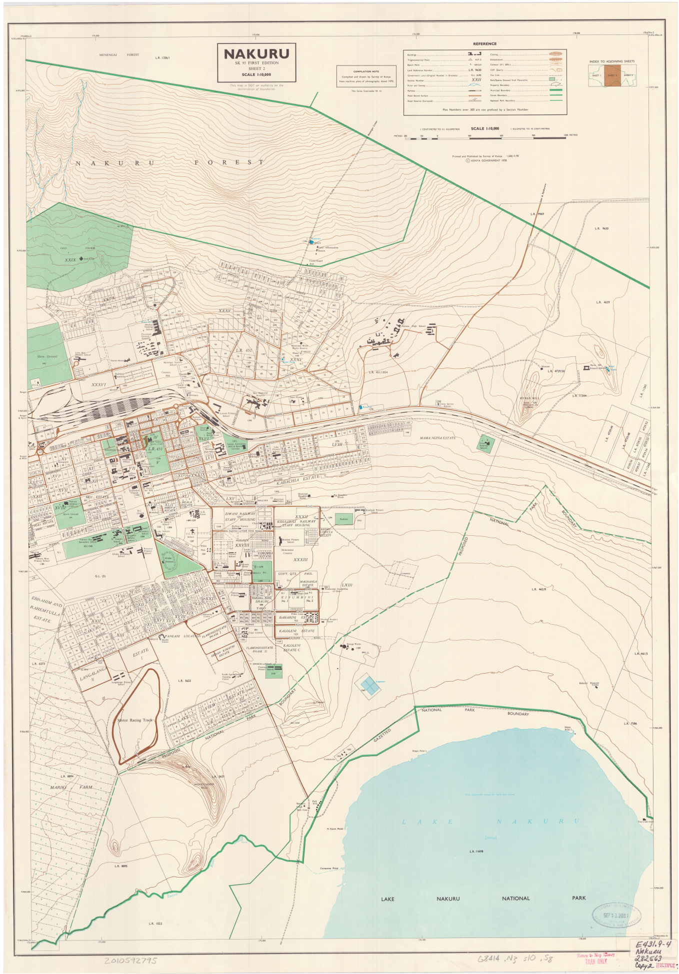
To qualify for inclusion, the paper maps had to be highly detailed. Many are multi-sheet panels of a city, often based on aerial photography. Figure SI.2 provides an example from Nakuru, Kenya, of how a historical map corresponds to the present-day (2020) street network data.

Table SI.3: Historical bands and map type by city

City:	Historical bands	Map type by year	Start date
Abuja, Nigeria	5 bands: 1977-1985, 1985-1991, 1991-2001, 2001-2010, 2010-2020	1985 (GE), 1991 (GE), 2002 (GE), 2010 (GE)	1977
Accra, Ghana	10 bands: 1877-1927, 1927-1945, 1945-1957, 1957-1966, 1966-1985, 1985-1991, 1991-2001, 2001-2008, 2008-2014, 2014-2020	1927 (paper), 1945 (paper), 1957 (paper), 1966 (paper), 1985 (GE), 1991 (Angel), 2001 (Angel), 2008 (GE), 2014 (Angel)	1877
Addis Ababa, Ethiopia	8 bands: 1886-1959, 1959-1964, 1964-1973, 1973-1986, 1986-1992, 1992-2000, 2000-2010, 2010-2020	1959 (paper), 1964 (paper), 1973 (GE), 1986 (Angel), 1992 (GE), 2000 (Angel), 2010 (Angel)	1886
Arusha, Tanzania	7 bands: 1835-1955, 1955-1967, 1967-1988, 1988-2000, 2000-2005, 2005-2013, 2013-2020	1955 (paper), 1967 (paper), 1988 (Angel), 2000 (Angel), 2005 (GE), 2013 (Angel)	1835
Bamako, Mali	7 bands: 1883-1966, 1966-1980, 1980-1990, 1990-2000, 2000-2008, 2008-2013, 2013-2020	1966 (paper), 1980 (paper), 1990 (Angel), 2000 (Angel), 2008 (GE), 2013 (Angel)	1883
Beira, Mozambique	7 bands: 1890-1969, 1969-1985, 1985-1991, 1991-2001, 2001-2007, 2007-2013, 2013-2010	1969 (paper), 1985 (GE), 1991 (GE), 2001 (Angel), 2007 (Angel), 2013 (Angel)	1890
Brikama, Gambia	6 bands: 1894-1971, 1971-1985, 1985-2004, 2004-2010, 2010-2017, 2017-2020	1971 (paper), 1985 (GE), 2004 (GE), 2010 (GE), 2017 (GE)	1894
Buchanan, Liberia	6 bands: 1832-1969, 1969-1985, 1985-1995, 1995-2003, 2003-2013, 2013-2020	1969 (paper), 1985 (GE), 1995 (paper), 2003 (GE), 2013 (GE)	1832
Bujumbura, Burundi	6 bands: 1899-1964, 1964-1985, 1985-2000, 2000-2008, 2008-2015, 2015-2020	1964 (paper), 1985 (GE), 2000 (GE), 2008 (GE), 2015 (GE)	1889
Cape Town, South Africa	10 bands: 1652-1806, 1806-1848, 1848-1937, 1937-1951, 1951-1975, 1975-1985, 1985-1994, 1994-2001, 2001-2012, 2012-2020	1806 (paper), 1848 (paper), 1937 (paper), 1951 (paper), 1975 (paper), 1985 (GE), 1994 (GE), 2001 (GE), 2012 (GE)	1652
Gaborone, Botswana	7 bands: 1964-1970, 1970-1985, 1985-1991, 1991-2000, 2000-2009, 2009-2015, 2015-2020	1970 (paper), 1985 (GE), 1991 (GE), 2000 (GE), 2009 (GE), 2015 (GE)	1964
Gombe, Nigeria	7 bands: 1824-1967, 1967-1985, 1985-1990, 1990-2000, 2000-2009, 2009-2013, 2013-2020	1967 (paper), 1985 (GE), 1990 (Angel), 2000 (Angel), 2009 (GE), 2013 (Angel)	1824
Ibadan, Nigeria	9 bands: 1829-1949, 1949-1960, 1960-1974, 1974-1978, 1978-1984, 1984-2000, 2000-2007, 2007-2013, 2013-2020	1949 (paper), 1960 (paper), 1974 (paper), 1978 (paper), 1984 (Angel), 2000 (Angel), 2007 (GE), 2013 (Angel)	1829
Johannesburg, South Africa	8 bands: 1886-1934, 1934-1964, 1964-1975, 1975-1985, 1985-1990, 1990-1998, 1998-2013, 2013-2020	1934 (paper), 1964 (paper), 1975 (paper), 1985 (GE), 1990 (Angel), 1998 (Angel), 2013 (Angel)	1886
Kampala, Uganda	7 bands: 1890-1963, 1963-1988, 1988-1996, 1996-2003, 2003-2008, 2008-2015, 2015-2020	1963 (paper), 1988 (Angel), 1996 (GE), 2003 (Angel), 2008 (GE), 2015 (Angel)	1890
Kara, Togo	5 bands: 1902-1985, 1985-1991, 1991-2011, 2011-2017, 2017-2020	1985 (GE), 1991 (paper), 2011 (GE), 2017 (GE)	1902
Khartoum, Sudan	10 bands: 1821-1883, 1883-1906, 1906-1946, 1946-1956, 1956-1965, 1965-1988, 1988-2000, 2000-2009, 2009-2014, 2014-2020	1883 (paper), 1906 (paper), 1946 (paper), 1956 (paper), 1965 (paper), 1988 (Angel), 2000 (Angel), 2009 (GE), 2014 (Angel)	1821
Kigali, Rwanda	8 bands: 1907-1967, 1967-1981, 1981-1987, 1987-1994, 1994-1999, 1999-2008, 2008-2014, 2014-2020	1967 (paper), 1981 (paper), 1987 (Angel), 1994 (paper), 1999 (Angel), 2008 (GE), 2014 (Angel)	1907
continued...			

Historical bands and map type by city (continued)

City:	Historical bands	Map type by year	Start date
continued from above...			
Kinshasa, DRC	8 bands: 1881-1930, 1930-1949, 1949-1967, 1967-1975, 1975-1994, 1994-2000, 2000-2013, 2013-2020	1930 (paper), 1949 (paper), 1967 (paper), 1975 (paper), 1994 (Angel), 2000 (Angel), 2013 (Angel)	1881
Lagos, Nigeria	9 bands: 1851-1931, 1931-1960, 1960-1978, 1978-1984, 1984-1992, 1992-2000, 2000-2007, 2007-2013, 2013-2020	1931 (paper), 1960 (paper), 1978 (paper), 1984 (Angel), 1992 (GE), 2000 (Angel), 2007 (GE), 2013 (Angel)	1851
Luanda, Angola	7 bands: 1627-1963, 1963-1978, 1978-1991, 1991-2000, 2000-2008, 2008-2014, 2014-2020	1963 (paper), 1975 (paper), 1991 (Angel), 2000 (Angel), 2008 (GE), 2014 (Angel)	1627
Lubumbashi, DRC	8 bands: 1910-1954, 1954-1969, 1969-1985, 1985-1990, 1990-1998, 1998-2006, 2006-2013, 2013-2020	1954 (paper), 1969 (paper), 1985 (GE), 1990 (Angel), 1998 (Angel), 2006 (GE), 2013 (Angel)	1910
Malabo, Equatorial Guinea	5 bands: 1827-1956, 1956-1985, 1985-2003, 2003-2007, 2007-2020	1956 (paper), 1985 (GE), 2003 (GE), 2007 (GE)	1827
Manzini, Eswatini	5 bands: 1885-1958, 1958-1979, 1979-1995, 1995-2009, 2009-2020	1958 (paper), 1979 (paper), 1995 (paper), 2009 (GE)	1885
Maputo, Mozambique	6 bands: 1850-1930, 1930-1967, 1967-1986, 1986-2004, 2004-2011, 2011-2020	1930 (paper), 1967 (paper), 1986 (GE), 2004 (GE), 2011 (GE)	1850
Maseru, Lesotho	7 bands: 1869-1957, 1957-1966, 1966-1975, 1976-1990, 1990-2002, 2002-2010, 2010-2020	1957 (paper), 1966 (paper), 1975 (paper), 1990 (paper), 2002 (GE), 2010 (GE)	1869
Monrovia, Liberia	8 bands: 1822-1946, 1946-1955, 1955-1975, 1975-1984, 1984-1992, 1992-2008, 2008-2015, 2015-2020	1946 (paper), 1955 (paper), 1975 (paper), 1984 (GE), 1992 (GE), 2008 (GE), 2015 (GE)	1822
Nairobi, Kenya	6 bands: 1898-1948, 1948-1962, 1962-1978, 1978-2004, 2004-2014, 2014-2020	1948 (paper), 1962 (paper), 1978 (paper), 2004 (GE), 2014 (Angel)	1898
Nakuru, Kenya	8 bands: 1904-1961, 1961-1975, 1975-1985, 1985-1989, 1989-2000, 2000-2006, 2006-2014, 2014-2020	1961 (paper), 1975 (paper), 1985 (GE), 1989 (Angel), 2000 (Angel), 2006 (GE), 2014 (Angel)	1904
Ndola, Zambia	8 bands: 1904-1959, 1959-1974, 1974-1985, 1985-1989, 1989-2002, 2002-2009, 2009-2014, 2014-2020	1959 (paper), 1974 (paper), 1985 (GE), 1989 (Angel), 2002 (Angel), 2009 (GE), 2014 (Angel)	1904
Oyo, Nigeria	7 bands: 1835-1917, 1917-1985, 1985-1990, 1990-2000, 2000-2007, 2007-2014, 2014-2020	1917 (paper), 1985 (GE), 1990 (Angel), 2000 (Angel), 2007 (GE), 2014 (Angel)	1835
Pointe Noire, Congo	7 bands: 1883-1925, 1925-1971, 1971-1984, 1984-1992, 1992-2000, 2000-2011, 2011-2020	1925 (paper), 1971 (paper), 1984 (GE), 1992 (GE), 2000 (GE), 2011 (GE)	1883
Port Elizabeth, South Africa	9 bands: 1820-1922, 1922-1947, 1947-1963, 1963-1984, 1984-1990, 1990-2001, 2001-2006, 2006-2013, 2013-2020	1922 (paper), 1947 (paper), 1963 (paper), 1984 (GE), 1990 (Angel), 2001 (Angel), 2007 (GE), 2013 (Angel)	1820
Porto Novo, Benin	7 bands: 1730-1930, 1930-1955, 1955-1971, 1971-1980, 1980-1992, 1992-2013, 2013-2020	1930 (paper), 1955 (paper), 1971 (paper), 1980 (paper), 1992 (paper), 2013 (GE)	1730
Touba, Senegal	7 bands: 1887-1965, 1965-1979, 1979-1989, 1989-2001, 2001-2009, 2009-2015, 2015-2020	1965 (paper), 1979 (paper), 1989 (GE), 2001 (GE), 2009 (GE), 2015 (GE)	1887
Windhoek, Namibia	8 bands: 1890-1955, 1955-1973, 1973-1985, 1985-1990, 1990-1998, 1998-2004, 2004-2010, 2010-2020	1955 (paper), 1973 (paper), 1985 (GE), 1990 (GE), 1998 (GE), 2004 (GE), 2010 (GE)	1890



(a) One section of Nakuru (1975), government aerial survey map

(b) Same section of Nakuru (2020), OSM data

Figure SI.2: By georeferencing (a) to (b), I can date which specific street segments as of (b) existed as of (a) (1975) and which must have emerged after. Repeating this process across multiple maps for a city allows me to date streets to specific time bands.

5 Auditing dates of gridded neighborhoods (pg. 23)

There could be concern that, contrary to my overall assumption of path dependence, some planned (gridded) neighborhoods today are redevelopments of earlier unplanned (ungridded) neighborhoods initially built at the same location under a different regime type. When true, I would be assigning the wrong value of the explanatory variable (regime type) to these neighborhoods. This concern primarily is about gridded neighborhoods, which may have begun as ungridded. Neighborhoods that are still ungridded today were virtually always ungridded throughout their existence.

To assess how extensive this measurement error is I randomly sample 100 highly gridded neighborhoods (O >0.83, in the top 20th percentile of post-colonial neighborhoods). I then go back through the specific maps or satellite images used for each neighborhood's city (Figure SI.3) and attempt to observe exactly when the current gridded layout for that neighborhood happened. I do not do this for every neighborhood in my data because this is an extremely time consuming process and because image/map quality differences mean it is not possible to positively identify the exact date each layout is first visible in some neighorhoods, even as the historical images/maps still allow me to date that the neighborhood's location was built urban settlement at a given time.[4]

After dropping 22 neighborhoods in the 100 for which the historical imagery is not sufficiently detailed for me to observe the layout at the time the neighborhood first appears, I can confirm my assumption of path dependence broadly holds in the remaining 78 gridded neighborhoods: 91% (71) have had the same gridded layout that they have today throughout their existence, suggesting there is no measurement error in attributing the present-day layout to the regime type as of their initial construction. Among the other 7 (9%), 3 (4%) were redeveloped to become gridded in a later period than their initial construction, but the country's regime type was the same in both periods, so the measurement error does not affect my coding of the explanatory variable and would not change my results. Only in 4 (5%) cases – two neighborhoods in Cape Town, one in Johannesburg, and one Addis Ababa – did the current gridded layout emerge at a later date from the initial construction under a regime with a polyarchy score sufficiently different to have changed whether the period is coded as a "high autocracy."

I then conduct a simulation analysis to assess how much of a risk this level of measurement error could pose. Applying the logic of randomization inference, across 1000 simulations I switch the high autocracy (explanatory variable) coding (0 vs. 1) for a randomly sampled 5% of highly-gridded neighborhoods (upper 80th percentile in griddedness) and re-estimate the main model in Table 1, panel (a), column 4. This test operates under the assumption that measurement error of this degree means that an unknown 5% of these observations have explanatory variable values potentially miscoded.

Figure SI.3 plots the distribution of resulting effect estimates from each of the 1000 runs. The effect for autocracy remains positive in 100% of cases. It is statistically significant at the $\alpha < 0.1$

[4]In particular, earlier satellite images from the 1980s and 1990s are at poorer resolution than the imagery available for later years. It remains easy to observe that urban settlement exists at a location from these images (mainly from color signature), but the images often aren't crisp enough to pick out individual residential streets and confirm their specific layout (Angel et al. 2016).

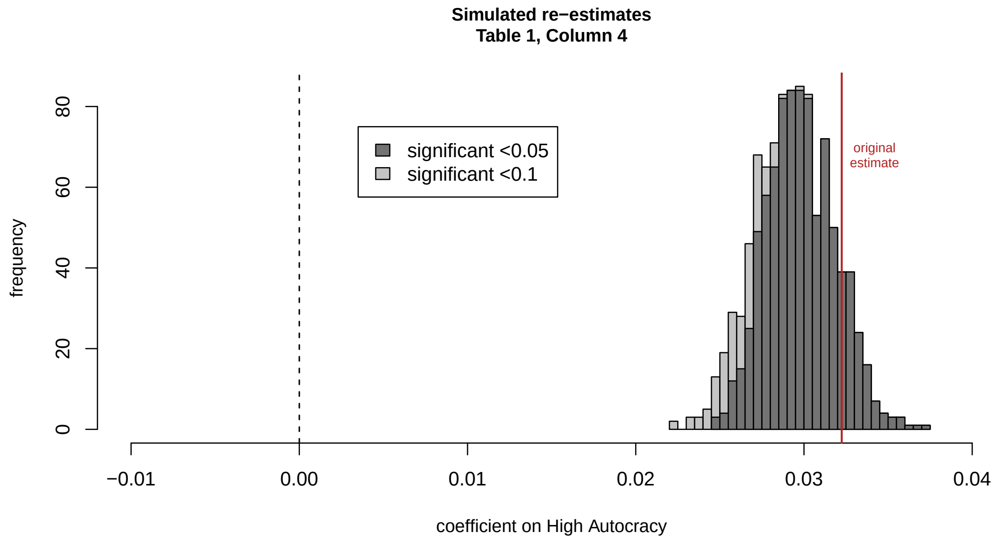


Figure SI.3: *Simulating measurement error in regime type values for gridded neighborhoods.*

level in 100%, and at the $\alpha < 0.05$ level in 88%. My observed effect size is also not an outlier. Ultimately, the true level of measurement error would have to be significantly larger than this for it to explain away my main result.

6 Robustness to after satellites are available (pg. 23)

To assuage concerns that the main result could be due to selective omission of certain types of neighborhoods from official paper maps, I repeat the main result for high autocracy from panel (a), column 5 of Table 1 (reproduced in column 1 of Table SI.4) after subsetting only to neighborhoods estimated to have been built on average after 1980. Beginning from the early 1980s, satellite imagery, either via Google Earth or Angel et al. (2016), replaces paper maps as the leading data source (see Table SI.3). Satellite images capture full built urban footprints without omissions. The result remains the same (column 2 of Table SI.4).

Table SI.4: Robustness to focus on post-1980 streets

Outcome: Orientation order (O) by neighborhood	1	2
High autocracy (0,1)	0.032^{*}	0.030^{**}
	(0.013)	(0.011)
Model type	OLS	OLS
City fixed effects	Y	Y
N	5525	4403
adj. R^2	0.361	0.345

† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. Standard errors are clustered at the country level.

7 Robustness to binary measure of autocracy vs. democracy (pg. 24, fn. 26)

Replacing the polyrachy score in Table 1 instead with a common binary coding of the overall autocracy-democracy distinction produces similar results. In Table SI.5 I instead use Geddes et al.'s (2014) binary classification of country-years into autocracy (0) or democracy (1). Geddes et al. (2014) update the famous coding schemed developed by Przeworski et al. (2000). I further update Geddes et al. (2014) to reach through 2020, the end time of my data. The predictor in Table SI.5 is the proportion of years when a neighborhood was built that the country was a democracy. I replicate the base models from column 1 of Table 1 for comparison.

8 Non-linear effects of polyarchy via GAM regression (pg. 27, fn. 32)

Polyarchy appears to have a non-linear relationship with griddedness. To demonstrate this, I turn to a Generalized Additive Model (GAM) to allow for a smooth response function between polyarchy and griddedness, while otherwise repeating the setup of column 1 in Panel (a) of Table 1 in the main text. The resulting estimated relationship between polyarchy and griddedness is visualized in Figure SI.4.[5]

[5]In this model I've set the number of basis functions to $k = 8$. The pattern in Figure SI.4 remains consistent across other reasonable choices of k.

Table SI.5: Robustness to using Geddes et al. (2014) democracy definition

Outcome: Orientation order (O) by neighborhood	1	2	3
Proportion years democracy (0-1)	-0.036^{*}	-0.039^{**}	-0.065^{**}
	(0.017)	(0.012)	(0.022)
Model type	OLS	MLM	OLS
City fixed effects	Y	N	N
City random effects	N	Y	N
Neigh.-level controls	Y	Y	Y
City-level controls	N	Y	Y
Country-level controls	N	Y	Y
N	5525	5525	5525
adj. R^2	0.361	$--$	0.329

† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.
Standard errors are clustered at the country level.

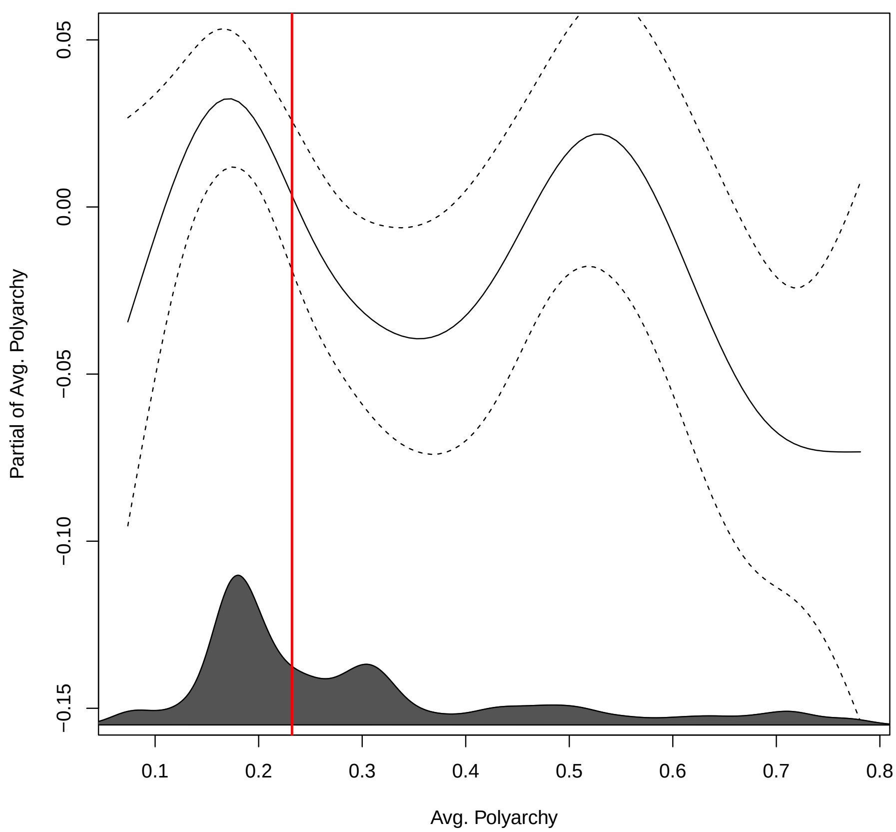


Figure SI.4: *Non-linear relationship between polyarchy and griddedness: GAM model.*

The median value of polyarchy (used as the cutpoint for defining the binary “high autocracy” variable) is indicated by the red vertical line and the density of neighborhood observations are indicated in the rug at the bottom of the plot. Figure SI.4 confirms that rather than griddedness linearly decreasing in polyarchy over polyarchy’s full range, the sharpest divergence is between neighborhoods built in very autocratic periods (below median polyarchy, which have very gridded streets) and less autocratic periods (above median polyarchy, which have less gridded streets) right around the median value of polyarchy, which is also where most of the mass of the sample is concentrated. This is the comparison that is driving the results for the “high autocracy” variable in the main text (columns 4-5 of Table 1). At very high levels of polyarchy (polyarchy > 0.5, akin to consolidated democracies), the relationship between polyarchy and griddedness appears to change again, but there are so few observations left in this range, as indicated by the density rug plot, that it is not clear if this is a meaningful result.

9 List of "high autocracies" (pg. 27, fn. 33)

Table SI.6 lists the years in my data that each city is coded as a "high autorcacy," along with the mean V-Dem polyarchy score in that set of years.

Table SI.6: List of "high autocracy" city-years

City	Years	Mean Polyarchy score
Abuja, Nigeria	1977 – 1978	0.20
Abuja, Nigeria	1984 – 1994	0.21
Abuja, Nigeria	1995 – 1998	0.21
Accra, Ghana	1966 – 1969	0.17
Accra, Ghana	1972 – 1978	0.12
Accra, Ghana	1981 – 1992	0.11
Addis Ababa, Ethiopia	1951 – 1991	0.08
Addis ababa, Ethiopia	1994 – 1995	0.21
Addis Ababa, Ethiopia	2010 – 2017	0.23
Bamako, Mali	1965 – 1991	0.16
Brikama, Gambia	1994 – 1996	0.14
Buchanan, Liberia	1951 – 1985	0.18
Buchanan, Liberia	1988 – 1996	0.19
Bujumbura, Burundi	1963 – 1992	0.12
Bujumbura, Burundi	1996 – 2004	0.20
Bujumbura, Burundi	2015 – 2020	0.17
Cape Town, South Africa	1951 – 1990	0.18
Gombe, Nigeria	1966 – 1978	0.19
Gombe, Nigeria	1984 – 1992	0.21
Gombe, Nigeria	1994 – 1998	0.21
Ibadan, Nigeria	1966 – 1978	0.19
Ibadan, Nigeria	1984 – 1992	0.21
Ibadan, Nigeria	1994 – 1998	0.21
Johannesburg, South Africa	1951 – 1990	0.18
Kampala, Uganda	1969 – 1989	0.14
Kara, Togo	1963 – 1991	0.13
Khartoum, Sudan	1959 – 1985	0.15
Khartoum, Sudan	1989 – 2014	0.16
Khartoum, Sudan	2019 – 2020	0.20
Kigali, Rwanda	1965 – 1965	0.18
Kigali, Rwanda	1973 – 1990	0.17
Kigali, Rwanda	1993 – 2020	0.18
Kinshasa, DRC	1965 – 2005	0.15
Lagos, Nigeria	1966 – 1978	0.19
Lagos, Nigeria	1984 – 1992	0.21
Lagos, Nigeria	1994 – 1998	0.21
Luanda, Angola	1976 – 2009	0.12
Lubumbashi, DRC	1965 – 2005	0.15
Malabo, Eq. Guinea	1969 – 2020	0.15
Manzini, Swaziland	1969 – 2020	0.13
Maseru, Lesotho	1969 – 1992	0.13
Monrovia, Liberia	1951 – 1985	0.18
Monrovia, Liberia	1988 – 1996	0.19
Nairobi, Kenya	1967 – 1991	0.20
Nakuru, Kenya	1967 – 1991	0.20
Ndola, Zambia	1974 – 1991	0.20
Oyo, Nigeria	1966 – 1978	0.19
Oyo, Nigeria	1984 – 1992	0.21
Oyo, Nigeria	1994 – 1998	0.21
Pointe Noire, Republic of Congo	1964 – 1990	0.11
Pointe Noire, Republic of Congo	1998 – 2002	0.17
Port Elizabeth, South Africa	1951 – 1990	0.18
Porto Novo, Benin	1966 – 1968	0.19
Porto Novo, Benin	1970 – 1990	0.11

Some regimes extend earlier than 1950, but as noted in the main text, 1950 is used as a cutoff to keep the analytic comparison within a similar time range for the small set of cases that decolonized much earlier (or where never colonized, e.g., Liberia).

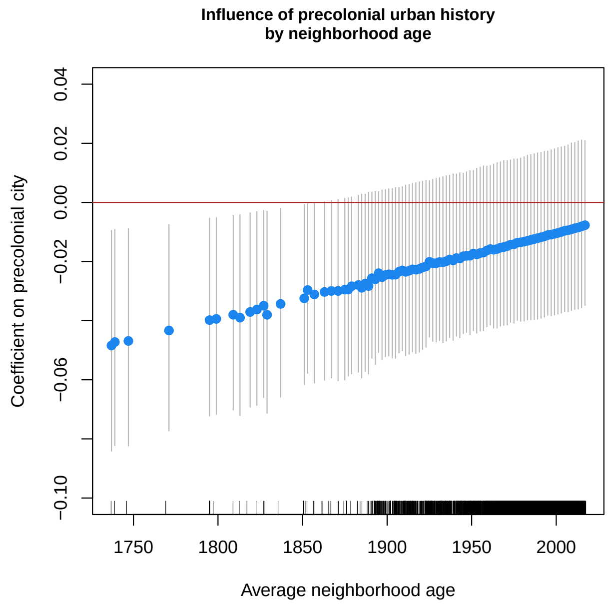


Figure SI.5: *Interaction of precolonial urbanization and neighborhood age*: coefficient estimate for precolonial urbanization's impact on order (O) (y-axis) simulated across the range of neighborhood age (x-axis), with 95% confidence intervals. The model repeats column 1 of panel (b) of Table 1, interacting the precolonial city control with neighborhood age.

10 Alternative explanations: planning cultures and ties (pg. 30)

A series of alternative explanations focus on planning cultures and design influences. Working chronologically, a first possibility is that differences in precolonial city-building continue to explain urban form. However, panels (b) and (c) of Table 1 already show the autocracy-griddedness relationship persists controlling for whether a city was a precolonial urban center (9 of the 36 cities pre-date colonial rule). In an additional model similar to column 3 of panel (b) of Table 1, visualized in Figure SI.5, I interact the control for pre-colonial urbanization with neighborhood age. For the very earliest neighborhoods, a history of precolonial urbanization predicts less gridded layouts. But this relationship decays over time, with no evidence precolonial urbanization relates to griddedness for neighborhoods from the post-colonial period.

Second, I assess the impact of the colonial experience. I find evidence that colonial regimes mattered for the legibility of colonial-era neighborhoods, but colonial legacies cannot explain the results in the text: my findings are for the much larger set of neighborhoods (73%) from the post-colonial period. All models in Table 1 already control for the colonial power(s) in each city, with post-colonial autocracy predicting griddedness irrespective of colonial history.

In Table SI.7, columns 1-4 compare neighborhoods built under colonial rule to those built after independence in the same city. Column 1 shows that, within cities, colonial-era neighborhoods are more gridded, on average, than later-built neighborhoods. However, this result may be unique to a particular type of city, not a general Africa-wide pattern. In column 2 of Table SI.7, I show that colonial-era neighborhoods were only more gridded in settler colonies. Column 3 then shows that colonial-era neighborhoods are also only more gridded in non-capital cities.

Table SI.7: Neighborhood-level griddedness (O) and colonial characteristics

Outcome: Orientation order (O) by neighborhood	1	2	3	4	5
% Built under colonial rule	0.095^{*}	0.025	0.233^{***}		0.301^{***}
	(0.043)	(0.039)	(0.015)		(0.064)
% Built under settler rule		0.002			0.153^{*}
		(0.039)			(0.065)
% Colonial * % Settler		0.122^{*}			
		(0.050)			
% Built while capital city			0.030		
			(0.054)		
% Colonial * % Capital			-0.209^{***}		
			(0.039)		
% Built under French rule				0.116^{**}	0.167^{**}
				(0.038)	(0.048)
% Built under British rule				0.112^{*}	
				(0.051)	
% Built under other col. power				0.082	
				(0.050)	
Model type	OLS	OLS	OLS	OLS	MLM
City fixed effects	Y	Y	Y	Y	N
City random effects	N	N	N	N	Y
N	7552	7552	7552	7552	685
adj. R^2	0.350	0.354	0.357	0.352	–

† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. Standard errors clustered at the country level for columns 1-4. Columns 1-4 focus on the full time span of neighborhoods, while column 5 restricts to neighborhoods in which at least 50% of street segments were built under either French or British rule.

Other analyses compare French vs. British colonial planning, as in Baruah et al. (2021). Column 4 of Table SI.7 separates out the colonial rule variable from columns 1-3 by colonial power and finds that neighborhoods built under French or British rule are similarly more gridded than later neighborhoods in the same cities. In column 5, however, I remove the city fixed effects and instead compare neighborhoods across cities in which the majority (>50%) of streets were built under either French or British control; within this restricted sample, I find that French colonial-era neighborhoods were more orderly on average than British colonial-era neighborhoods.

A final way in which colonial legacies may matter is through their impact on property rights institutions. Boone (2014) shows that Africa's former settler colonies tend to have fundamentally different post-colonial land regimes than non-settler colonies, which may impact urban land use patterns in ways that could affect street layouts. Panels (b) and (c) of Table 1 in the main text already control for whether each city is in a former settler colony. But in Table SI.8 I now report the coefficient on the settler colony control from Table 1, panel (b), column 4 and then interact the settler colony control with the high autocracy explanatory variable. Being a former settler colony – and thus more likely to have state-dominated rather than neo-customary land rights in the post-colonial period – does not predict griddedness at the neighborhood level and does not interact with the effect of autocracy.

Third, there could be an effect of post-colonial planning cultures or influences. In Table SI.9 I examine periods that each country was closely linked to a different foreign benefactor – be it Soviet (or Eastern bloc), Western, or, in more recent decades, Chinese – from which different urban design ideas may have flowed (e.g., via the role of external experts advising on development projects). I draw on several data sources. First, Casey (2020) provides a global dataset of every

Table SI.8: Robustness to controlling for history as settler colony

Outcome: Orientation order (O) by neighborhood	1	2
High autocracy (0,1)	0.033***	0.028**
	(0.008)	(0.010)
Settler colony (0,1)	−0.111	−0.113
	(0.081)	(0.081)
High autocracy * Settler colony		0.009
		(0.015)
Model type	MLM	MLM
City random effects	Y	Y
Neigh.-level controls	Y	Y
City-level controls	Y	Y
Country-level controls	Y	Y
N	5525	5525

† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.
Standard errors are clustered at the country level.

year during which a country could be considered a Soviet (or Eastern bloc) client state, a Chinese client state, or a Western (US or other NATO power) client state, both during and after the Cold War. No African countries are coded in Casey's (2020) data as Chinese clients, so I focus first on a comparison of Soviet vs. Western client states.

In columns 1 and 2, I repeat model 4 from Table 1, panel (a), but now include a measure of the average proportion of years in the band(s) during which a neighborhood was built that its country was a Soviet client state. While neighborhoods built by Soviet client states are marginally less gridded overall, the relationship between high autocracy and griddedness is unaffected and does not interact with status as a Soviet client state. In column 3 and 4, I instead include a similar measure for neighborhoods built during periods as Western client states. Again there are no differences in the relationship between autocracy and griddedness, and no interaction.

An alternative way to measure potential for foreign influence is through the general ideological predisposition of regimes. In the Cold War period, more socialist regimes, even if not full Soviet clients, may have had more exchanges with and influence from Soviet-aligned architects and planners (Stanek 2020). V-Dem codes annually the degree to which state leaders professed a socialist ideology. I include this as a control in column 5 of Table SI.9 and interact it with the high autocracy indicator in column 6. I again find no differences in the autocracy-griddedness relationship and no interaction.

Since 2000, Chinese influence has also rapidly grown in Africa. Using data on Chinese spending and investment in Africa from the Johns Hopkins China-Africa Research Initiative,[6] I code differences in the degree of Chinese influence in two ways. In columns 7 and 8 of Table SI.9, I include an indicator of the proportion of years in each neighborhood's time band in which the city's country was among those receiving an above-average amount of Chinese foreign direct investment

[6] `http://www.sais-cari.org/chinese-investment-in-africa`.

(FDI) relative to the rest of Sub-Saharan Africa.[7] I again find null results.

In columns 9 and 10 of Table SI.9, I instead leverage detailed, project-level data on Chinese foreign development loans to each African country.[8] I code those that included investments in some form of physical infrastructure in each specific city in my sample and then create a yearly indicator for there having been such a program active within the last 5 years, to capture the period after a loan is initiated during which it is most likely that Chinese planners and architects working on associated urban development projects were active on the ground. I again find null results: te relationship between high autocracy and griddedness is unaffected and there is no interaction.

[7] Since around 2000, China has made investments in almost every African country, so this measure captures the countries with particularly large Chinese investment influence. Before this period, Chinese investment was instead negligible throughout the continent, so all neighborhoods built before 2000 are coded as having no Chinese investment influence.

[8] Boston University Global Development Policy Center. 2023. Chinese Loans to Africa Database. Retrieved from `http://bu.edu/gdp/chinese-loans-to-africa-database` 20 May 2024.

Table SI.9: Controlling for foreign links and influences

Outcome: Orientation order (O) by neighborhood	1	2	3	4	5	6	7	8	9	10
High autocracy (0,1)	0.038***	0.038***	0.032**	0.031**	0.033*	0.047*	0.042***	0.045***	0.041***	0.040***
	(0.010)	(0.010)	(0.011)	(0.011)	(0.016)	(0.018)	(0.012)	(0.011)	(0.009)	(0.009)
Proportion years Soviet client	−0.077†	0.007								
	(0.041)	(0.109)								
High autocracy * Soviet client		−0.085								
		(0.124)								
Proportion years Western client			0.012	−0.066						
			(0.075)	(0.140)						
High autocracy * Western client				0.080						
				(0.118)						
Average V-Dem socialism score					0.024	0.045				
					(0.068)	(0.072)				
High autocracy * Socialism score						−0.055				
						(0.063)				
Proportion years high Chinese FDI							0.025	0.031		
							(0.022)	(0.023)		
High autocracy * Chinese FDI								−0.052		
								(0.036)		
Proportion within 5 years of Chinese loans									0.044	0.042
									(0.033)	(0.041)
High autocracy * Chinese loans										0.007
										(0.045)
Model type	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*	*OLS*
City fixed effects	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*
N	5525	5525	5525	5525	5525	5525	5525	5525	5525	5525
adj. R^2	0.362	0.362	0.361	0.361	0.361	0.362	0.362	0.362	0.362	0.362

† significant at $p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. Standard errors are clustered at the country level. Explanatory variables are the proportion of years when each neighborhood was built averaged over the street segments within the neighborhood.

11 Tests for "protest proofing" (pg. 32)

I test the "protest proofing" mechanism in three ways in Table SI.10. First, I construct a time series dataset on major contentious episodes in each city to estimate whether neighborhoods built amidst, or soon after, moments of urban unrest are more likely to be gridded. I combine three data sources: (a) Chenowith and Shay's (2019) Nonviolent and Violent Campaigns and Outcomes (NAVCO v 2.1) dataset provides cross-national time-series data on major contentious campaigns, defined as any "maximalist" efforts intended to overthrow a state regime that had at least 1000 estimated participants in a given year. I restrict to events that were primarily urban; (b) Thomson et al.'s (2022) Urban Social Disorder (USD v 3.0) dataset. For comparability to NAVCO's definition of a contentious episode, I include all events USD codes as having more than 1,000 participants and being targeted at the regime; and (c) attempted coup d'etats (successful or unsuccessful) compiled from multiple data sources by LaChapelle (2020). The ability of both incumbent regimes and coup plotters to deploy troops through the streets of the capital can be crucial to whether coups succeed, as is whether the urban populace mobilizes in response. Periods with coup attempts also should be times when regimes should be especially concerned with their ability to deter popular urban mobilization.[9] I include coup attempts as contentious episodes in capitals only. I calculate two variables at the neighborhood level: (a) the proportion of years in each historical band in which a contentious episode happened, which is then averaged over all streets in the neighborhood; and (b) the proportion of years in each historical band that were up to 5 years after a contentious episode, which is then again averaged over all streets in the neighborhood.

Columns 1 and 3 of Table SI.10 show that the relationship between autocracy and grids persists controlling for either measure of contention.[10] Columns 2 and 4 show that the high autocracy variable also does not interact with the contention variables.

Second, columns 5-6 of Table SI.10 test how the location of each neighborhood relative to the central area of state power in each city affects the neighborhood's griddedness. I geolocate the specific building most associated with the state in each city for each year from 1950-2020. In capitals, this is the presidential palace; for provincial capitals, the provincial headquarters; and for the remaining cities, the city hall. I calculate the distance (in km) of each street segment in each city to these locations and assign neighborhoods the average distance of their streets to these nodes of state power at the time those streets were built. In column 5, I find that the autocracy-griddedness relationship persists controlling for neighborhood locations relative to state headquarters. In column 6, I show that this distance and autocracy do not interact.

Third, column 7 of Table SI.10 explores whether neighborhoods that are better connected to major boulevards, operationalized as non-residential roads in OSM's classification scheme, emerge more often under highly autocratic regimes. I measure the shortest distance (in km) *traveling through the street network* from each street to the nearest major road, subsetting to major roads in

[9] I also repeat the analyses in Table SI.10 excluding the coup attempts, relying only on the NAVCO and USD data. I find identical results.

[10] In column 3, I even find that neighborhoods are on average *less* gridded in the aftermath of periods of contention, the opposite of what Scott's (1998) examples would predict.

Table SI.10: Testing implications of a "protest proofing" mechanism

	1	2	3	4	5	6	7
*O*utcome:	Order (O)	Order (O)	Order (O)	Order (O)	Order (O)	Order (O)	Avg. dist to boulevards
High autocracy (0,1)	0.031*	0.042*	0.033*	0.049†	0.029*	0.004	−0.015
	(0.015)	(0.021)	(0.015)	(0.027)	(0.013)	(0.025)	(0.102)
Contention (prop. years in band)	−0.016	0.010					
	(0.020)	(0.027)					
Contention * high autocracy		−0.039					
		(0.038)					
Contention in past 5 years (prop. years in band)			−0.041*	−0.025			
			(0.018)	(0.035)			
Contention in past 5 years * high autocracy				−0.035			
				(0.059)			
Avg. distance (km) to state HQ					−0.001	−0.001	
					(0.002)	(0.002)	
Avg. distance * high autocracy						0.002	
						(0.001)	
Average age							0.041***
							(0.007)
Model type	OLS	OLS	OLS	OLS	OLS	OLS	OLS
City fixed effects	Y	Y	Y	Y	Y	Y	Y
N	5525	5525	5525	5525	5525	5525	5525
adj. R^2	0.361	0.361	0.362	0.362	0.361	0.356	0.260

† significant at $p < .10$; $^*p < .05$; $^{**}p < .01$; $^{***}p < .001$. Standard errors clustered at the country level.

existence as of when that street was built, and then average over all streets in each neighborhood. Although there is a very clear time trend – with neighborhoods emerging in more recent years less integrated with large boulevards – autocracy (or polyarchy) are uncorrelated with this outcome.

Finally, each pattern in Table SI.10 is also robust to subsetting only to capital cities (not shown for space constraints), such that these patterns hold even in the cities in which the threat of protest is likely most pressing to autocrats.

12 Unpacking the fixed effects (pg. 33)

Figures SI.6 and SI.7 "unpack" the fixed effects in columns 4 and 5, respectively, of panel (a) of Table 1, estimating separate within-city regressions by city. Cities without internal variation in high autocracy are dropped. The green vertical lines represent the full relationship in the overall sample.

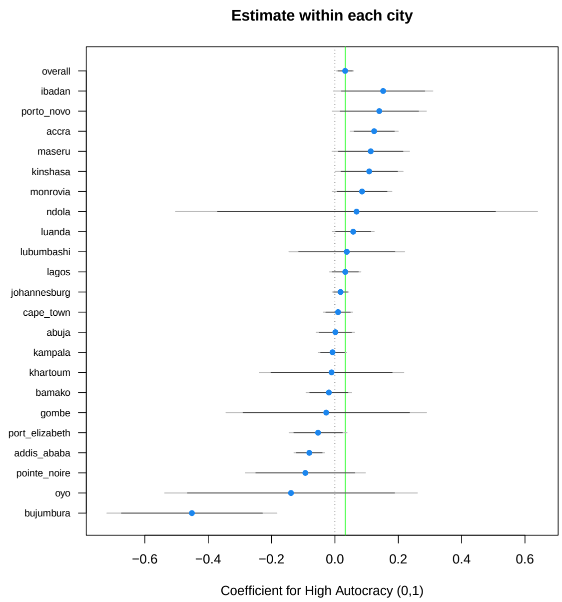


Figure SI.6: *Unpacking the fixed effects to select cases:* coefficients for “high autocracy,” as in column 4 of Panel (a) of Table 1, but estimated separately for each city, with 90% and 95% confidence intervals

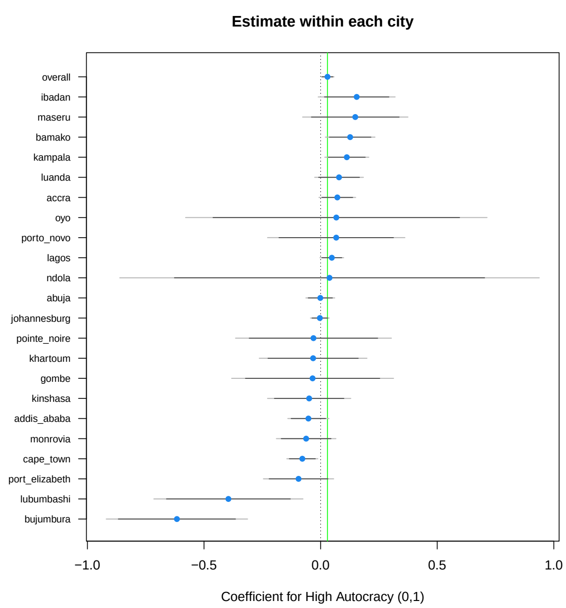


Figure SI.7: *Unpacking the fixed effects to select cases:* coefficients for “high autocracy,” as in column 5 of Panel (a) of Table 1, but estimated separately for each city, with 90% and 95% confidence intervals

13 Housing investments by state capacity and ideology (pg. 33)

Breaking down the state housing construction coded from the case studies, there is a clear pattern that poorer (lower GDP) states engage in relatively more "sites-and-services" than direct construction, consistent with the choice between these options being a function of state capacity and resource constraints. Mean GDP per capita in a city-year with direct state housing construction is \$4,499.00 versus \$1,493.10 in a city-year with "sites-and-services" construction.

The probability of state housing construction (of either type) also varies marginally with regime ideology. There is state housing construction in 44% of city-years with regimes with above average V-Dem socialism scores in the sample (the mean V-Dem socialism score is 0.21 on a 0-1 scale). By contrast, there is state housing construction in 36% of city-years with below average socialism scores. Note, however, that this difference may be driven entirely by the ANC's housing investments in post-Apartheid South Africa. Removing the three South African cities, there is only state housing construction in 33% of city-years with above average regime socialism scores, effectively no different from the rate in non-socialist regimes.