Building African Cities[1] *Science* 29/03/2016

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Cities in many parts of the developing world do 'not function well' (WB, 2009), as is reflected in: (1) hotchpotches of land uses throughout cities with office towers bordered by slums, and scattered fringe developments; (2) huge portions of people in low quality of life 'slums', totalling 62% of the African urban population (UN Habitat, 2012); (3) poor transport, congestion, and a lack of clustering of economic activity, all resulting lower productivity (IAPT, 2010). We look at functionality through the lens of the evolution of the built environment to make key points.

Efficient evolution of cities involves on-going reconstruction with increasing building heights and on-going relocation and redevelopment of slums with potentially their eventual demise. It also requires functional institutions to minimize land market frictions. Poor institutions in Africa and parts of Asia profoundly affect the efficient building of cities in dimensions we will discuss. It is critical to note that over 2/3 of the produced capital in developing countries is in housing, land and buildings (WB, 2006) and most public infrastructure involves urban transport. Such capital is long lived, lasting for decades and even centuries. Decisions made today based on expectations about future city growth determine the building of cities. Get it badly wrong today, either because of land market frictions or uninformed expectations, and the effects last generations.

In Henderson, Regan and Venables (2016) [hereafter HRV], we develop a model of a growing city with durable capital (Braid, 2001), adapted to developing country contexts. We start with deriving benchmark efficient development paths, where there are no land market frictions and builders have perfect foresight. We assume the city's relative productivity grows over time, raising incomes and drawing people into the city. With growth the city expands and densifies as housing rents and land values rise. The city is monocentric, as people commute to work in the central business district [CBD] (Duranton and Puga, 2015). Land use intensity varies by distance to the CBD driven by land price gradients, where prices decline sharply with distance from and poorer access to the CBD. There are two types of housing technology. One is formal sector which is 'putty-clay': upon construction developers choose height which is then fixed until the building is demolished, all capital demolished, and reconstruction occurs. In the informal sector, building to one storey high is cheaper than in the formal sector and construction is flexible or adjustable over time (cinder blocks/ LEGOs); but building high is very expensive compared to the formal sector, or impossible.

Under efficient paths, the informal settlement is restricted to the city fringe. Why? Its technology (cheap single story housing) is best suited to locations at the edge where land is cheapest. Moving towards the city centre, informal settlement gives way to formal sector development one or two storeys high, and then increasingly intense development and taller buildings at more expensive locations nearer the CBD. Over time, expansion at the edge is in the informal sector; older informal sector areas convert to formal as prices rise; and nearer the CBD old formal sector buildings are demolished and replaced with taller buildings. There are two additional dimensions. First, if informal sector housing is perceived to be lower quality by consumers, eventually as incomes rise the informal sector disappears, just as the tenements in New York and London from 125 years ago disappeared long ago. Second, as the first source of inefficiency, if developers under-forecast the growth rate of house prices, the city will be built too short, with fewer people.

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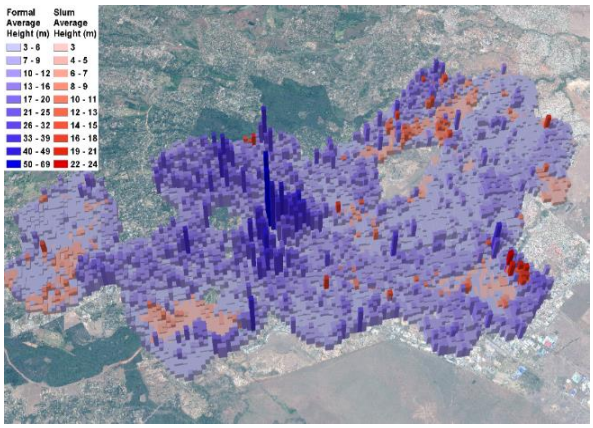
Next we come to land market frictions. Formal sector development requires financing, insurance, and enforcement of contracts which in turn requires land ownership rights to be formalized to mitigate the risk of expropriation and long court cases over competing claims. Generally in Africa, there is a mixture of formal rights and of informal rights such as communal, plots with competing private claims, and government ownership. The last can translate into messy situations: land granted without title in the past, which then develops a set of competing legal (and illegal) claims. Potentially, informal rights can be formalized at some perhaps very high cost, so informal land can be converted for formal use. The cost of conversion varies by plot histories and locations in the city, and plots with high conversion costs remain informal much longer. In the model a spatial hotchpotch of land rights and conversion costs results in a hotchpotch of uses and different intensities of land use and stages of redevelopment through the city. This matters as land, the city's ultimate scarce factor, is not being utilised efficiently.

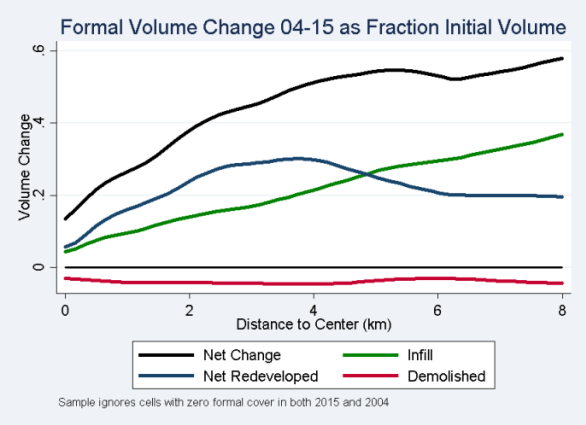
To study all this empirically with some degree of precision requires extremely high resolution aerial photo or satellite data to derive building polygons/footprints and road coverage, and LIDAR data for building heights. This is needed for at least two well separated time periods to study dynamics. It helps to have house and land prices data from surveys or scraping the web, and to have maps demarcating slums and their ownership/land rights. We have access to these data for a few African cities and have developed appropriate methodologies which are novel. Some work involves classifying urban land use and intensities from satellite data. Here the innovation concerns methods to overlay building polygon layouts of a city at different points in time to define infill, reconstruction, demolition and no change.

We report on the analysis in HRV of Nairobi, a city of about 5 million, growing in population at 3-4% a year. We have results on the urban cross-section and on the dynamics of redevelopment between 2004 and 2015. In the cross section, 2015 land prices decline sharply with distance from the CBD. Slums, at any distance, only cover a fraction of the land occupied by the formal sector; averaging across distance bands, the fraction peaks at 45%, at 5km out from the CBD. There are no slums in the CBD and, the area near the centre with absolutely no slums expands over time. However slums appear in a hotchpotch fashion throughout, indicating potentially significant land market frictions. Heights in the formal sector *average* about 23 meters in the CBD, indicating there is height in African cities such as Nairobi. Heights decline sharply, falling to about 6-7 meters at 10 kms out. As the model predicts, slums are everywhere less than in the formal sector and are basically flat throughout the city at about 5 meters. Building volumes (height x footprint) in the formal sector average about 120,000 cubic meters per 150x150 meter grid square near the centre but decline to about 40,000 by 5kms out and then are flat. In slum areas there is intense building ground coverage compared to the formal sector, with much less green space and roads, as expected. However, as a new finding, overall height in the formal sector trumps intense ground coverage in slums: volume *intensity* in the formal sector is always higher than in slums. Volume of building space per unit land in slums is just 16% that of formal buildings near the centre, rising to 90% at 5km and then declining somewhat. The 3-D map illustrates heights, slum coverage, monocentricity, a Nairobi geographically constrained by large national parks to the north and south, and the huge 1000 acre slum of Kibera to the south-west of the centre. Undefined spaces include an airport, golf course, and the President's complex.

What about the dynamics? The graph on formal sector volume changes shows, as a fraction of initial volume, infill (new buildings where there were none in 2004), net redevelopment (new building space minus the old building space it is built over) and demolition (old buildings yet to be replaced). There are several take-aways. In the 0-1 km ring at the centre, use is locked in by roads, colonial buildings, and tall complexes built over the last 40 years. We note that near the centre land in roads

is about 23% of total area which declines sharply with distance, as modelled in Solow and Vickery (1971). From 1- 5kms there is substantial net redevelopment with new buildings taller than their older neighbours. New net replacement volume at the peak at 4kms out amounts to over 30% of old volume. After 5kms volume changes are dominated by infill.





What about slums? Up to about 2kms, slums are demolished and redeveloped. After that patterns are pretty flat, with less redevelopment than might be expected. Why? In HRV, we argue that remaining slums like Kibera nearer the CBD have high costs of conversion to formal usage. According to IPE (2012), slum land near the centre including Kibera is government owned, a code word for conflicting private claims with the government having seized ownership but not responsibility. Slum landlords there make high profits and much of the land is controlled by political figures who have a vested interest in non-redevelopment. Redevelopment would take away their land on which they make profits but to which they have no legal claim. Nearer the fringe land ownership in slums becomes increasingly private. The constraint on slum redevelopment nearer the centre has at least two sources of significant welfare costs: there is lost volume of space due to not building high and the quality of the built space and unit rents are low, compared to the formal sector. We hypothesize that slum landlords have invested little in land improvements such as infrastructure and regularized lay-out near the centre since they cannot capture those returns when housing spaces are redeveloped. In HVR, a back of the envelope calculation suggests just the quality differential from lack of redevelopment reduces land values in Kibera by the order of $1b USA, a magnitude which indicates the potential to buy-out the actors inhibiting redevelopment and help relocate tenants.

Nairobi has features of a 'normal' city: high buildings in the CBD and declining heights and land prices away from the centre. In terms of volume of building space, despite the intense building cover in slums, height trumps cover: volume intensity is higher everywhere in the formal sector than in slums. Slum redevelopment is inhibited by high land market frictions resulting in a hotchpotch of slum and formal sector development through the city. While extreme land prices very near the centre have overcome land markets frictions to induce slum redevelopment, huge chucks of slum land at 3-5 kms out remain paralyzed in poor usage, with significant welfare losses.

References

1. Braid, R M., 2001. "Spatial Growth and Redevelopment with Perfect Foresight and Durable Housing," Journal of Urban Economics, 49(3),425-452
2. Duranton G and D Puga, 2015. "Urban Land Use" in Handbook of Regional and Urban Economics, G. Duranton. J.V. Henderson and W. Strange (eds). Elsevier
3. Henderson J.V., T. Regan and A. Venables, 2016. "Building the city: sunk capital and sequencing". CEPR WP # xxxx

4. International Association of Public Transport [IAPT], 2010, Major Roads and Case studies
5. Solow, R M. and W.S. Vickrey, 1971. "Land use in a long narrow city," Journal of Economic Theory, Elsevier, vol. 3(4), pages 430-447, December.
6. UN Habitat 2012, State of the Worlds' Cities, United Nations New York
7. World Bank, 2006, Where is the Wealth of Nations; Measuring Capital for the 21st Century, World Bank, Washington DC
8. World Bank (2009), World Development Report 2009: Reshaping Economic Geography, World Bank Washington DC