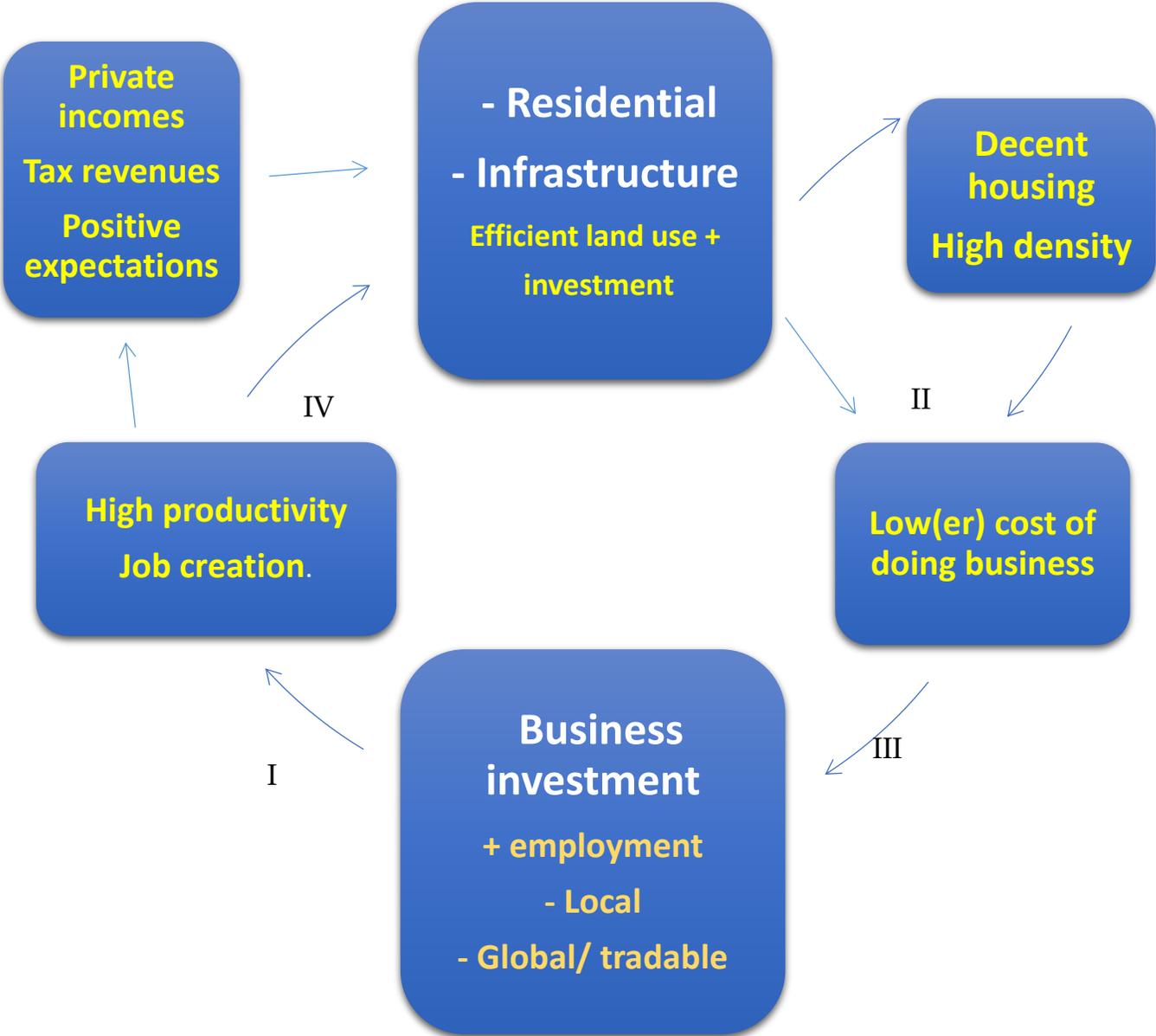# Urban framework

& research in progress

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(& Louise Bernard, Julia Bird, Vernon Henderson, Tracy Jones, Tanner Regan)

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International Growth Centre

Urban framework:

Research in progress:

- The urban model: spatial computable equilibrium model:
  - Application to Kampala
    - Implications of land tenure systems
    - Infrastructure improvement and connectivity

- A dynamic model: building functional cities:
  - Application to Nairobi
    - Transition from informal → formal → demolition and redevelopment
    - Cost of barriers to formalisation

- The production sector:
  - Tradable and non-tradable sectors: decreasing or increasing returns to urban growth?
  - Intra-urban clustering: (Kampala)

- The residential sector:
  - Who lives where? (Nairobi, Kigali, Lusaka)

Computable General Equilibrium Model

Motivation:

- Framework to capture the *interaction* of all elements of the city

Elements:

Geography

- City (Kampala) divided into 96 cells (parishes) + RoW
- Each cell has given land area & transport connections to other cells.

Producers: 3 sectors (tradable services, local services, manufactures):

- Firms choose location, inputs, sales to maximise profits.
- Different scale firm: monopolistic competition, producing differentiated goods/ services:
- Costs of delivering goods/ services between cells
- Inputs: High skill labour, low skill labour, land, intermediate goods and services.
- Productivity: localisation economies and sector-location specific local productivity parameters

Computable General Equilibrium Model

Households: 2 types (high skill/ low skill):

- Choose location of residence, type (formal or informal) and size of house, place of work, quantities of goods/services to consume,
- High skill have access to motorised transport, low skill do not
- Location specific amenity parameter.

Developers/ builders:

- 'Developers' build floor space of informal or formal houses

  Informal: low construction cost, but expensive to build tall .

  Formal: high construction cost, but cheaper to build tall

Equilibrium

- Wages, land rents, and prices of goods and houses (floor space) in each place are such that supply equals demand in all markets.

Computable General Equilibrium Model

Data: Kampala

- **Households:**
    - Population working in high-skilled/low-skilled jobs, and living in formal/informal housing.
    - Census, at the Parish level (96 cells)
- **Employment:**
    - Census of Business Establishments 2011 giving employment numbers with coordinates.
    - 3 sectors + government, determined from ISIC4
- **Transport costs:**
    - Generated from open street map road network
    - Travel speeds estimated using limited information on travel flows within the city.
   - Differentiated according to motorised or pedestrian.
- **Parameters:**
    - Elasticities, shares from secondary sources

Calibration

- Find parameters of the model so equilibrium exactly fits the data on Kampala.
- Calibrated amenity and productivity parameters summarise information about determinants of location that are not in the formal model.

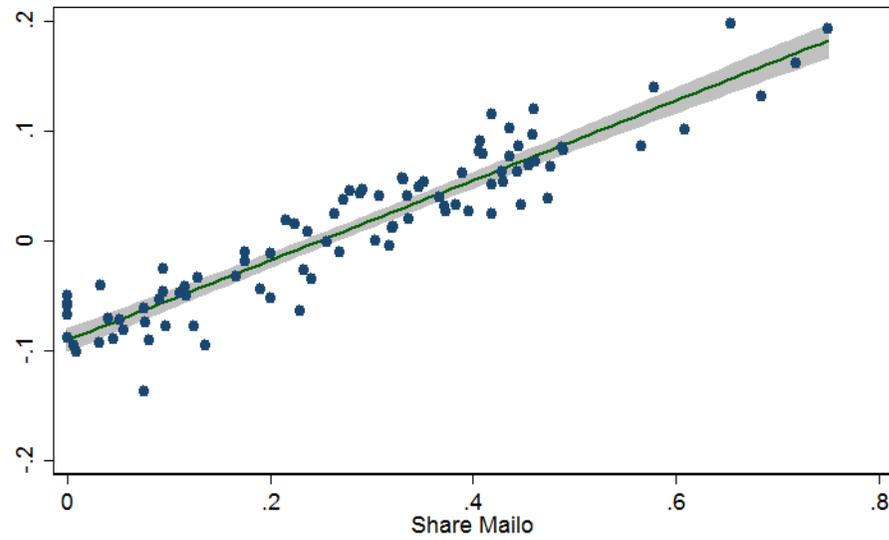# Computable General Equilibrium Model

E.G.: computed equilibrium rents
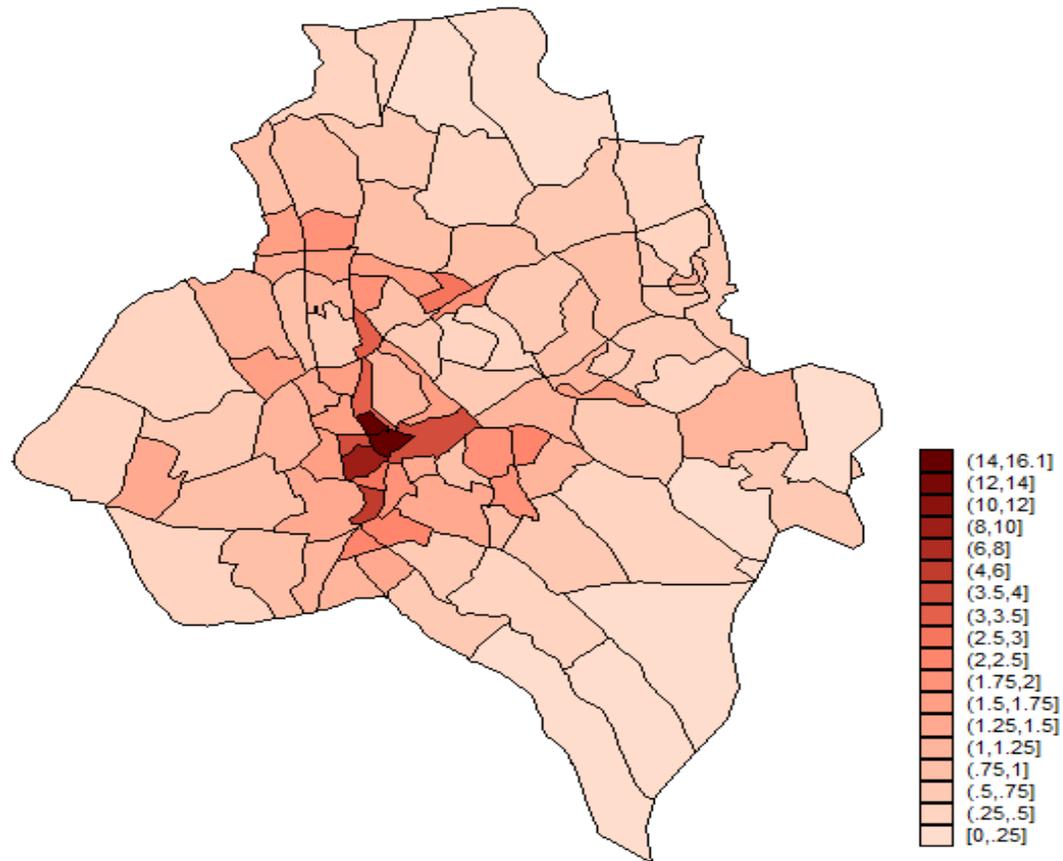
1. Freehold
2. Leasehold
3. Customary

    Tenants on land have the rights preventing them for being evicted, and allowing conversion of land to leasehold or freehold status. Disputed claims

4. Mailo

    Held by private individuals or Buganda Kingdom. Separation of ownership between land and structure is permissible. Disputed claims.
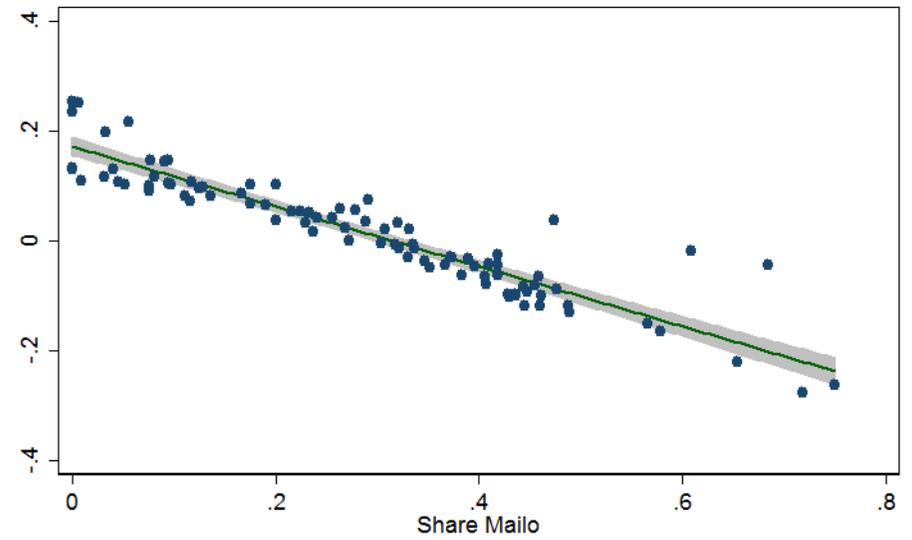

Land Tenure Type
- Mixed
- Customary
- Freehold
- Leasehold
- Mailo land

0 0.75 1.5   3   4.5   6
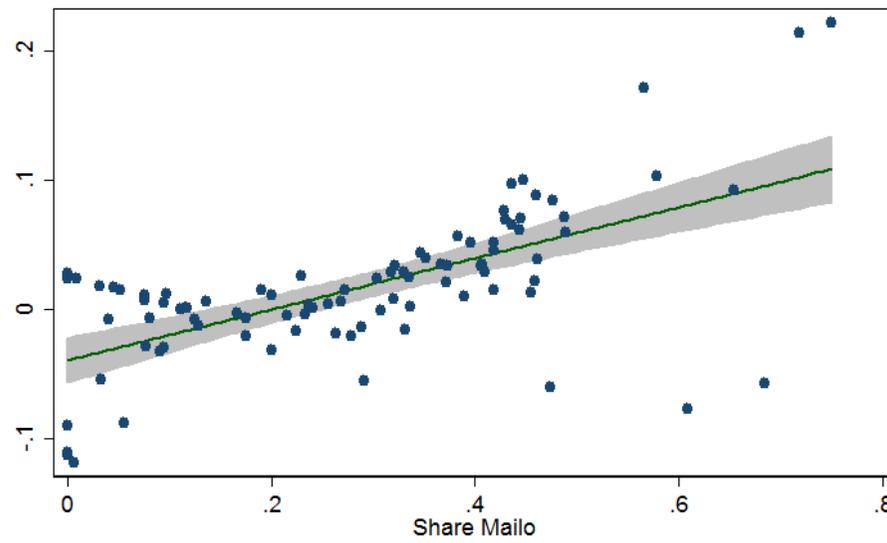Kilometers
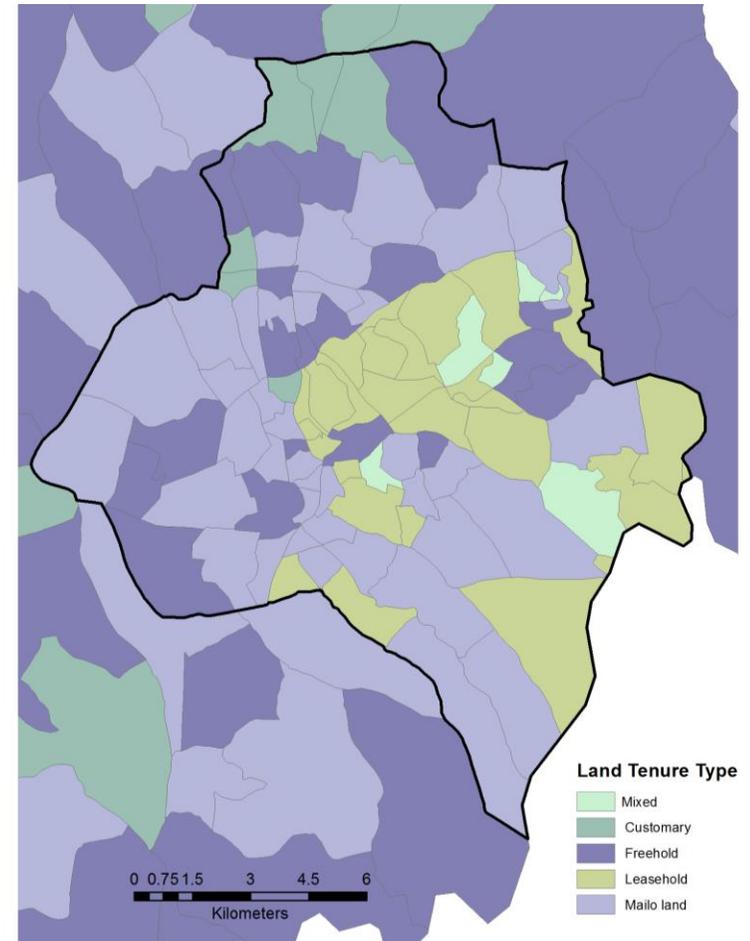
What happens?

Proportionate change in Employment

Change in Population

Change in Land Rents

# Dynamics of growth: building functional cities

- How do fast growing cities get built?

    - Development by formalisation/ demolition/ infill/ spread

    - Informal sector – 'lego' or putty-clay.

    - Formal sector – sunk capital: **expectations matter**

    - Conversion costs in making transition from informal to formal

- Theory

    - Development path with foresight and uniform conversion costs

    - The role of expectations

        - Perfect foresight?

        - Pessimistic: Lower buildings, sprawl, welfare loss

    - Heterogeneous conversion costs:

        - The social cost of delayed conversion

City development

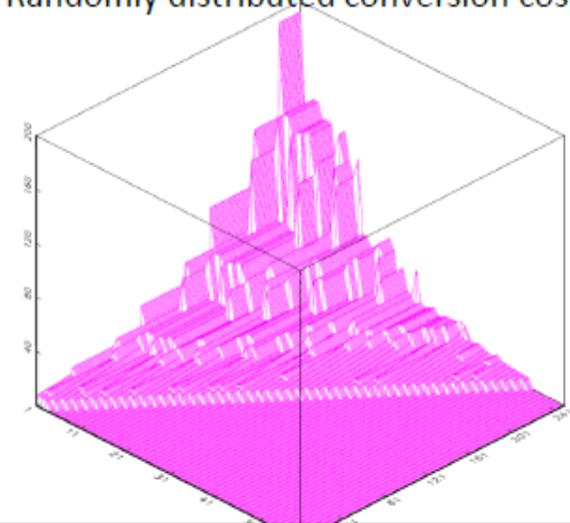## Same first time (D) conversion costs
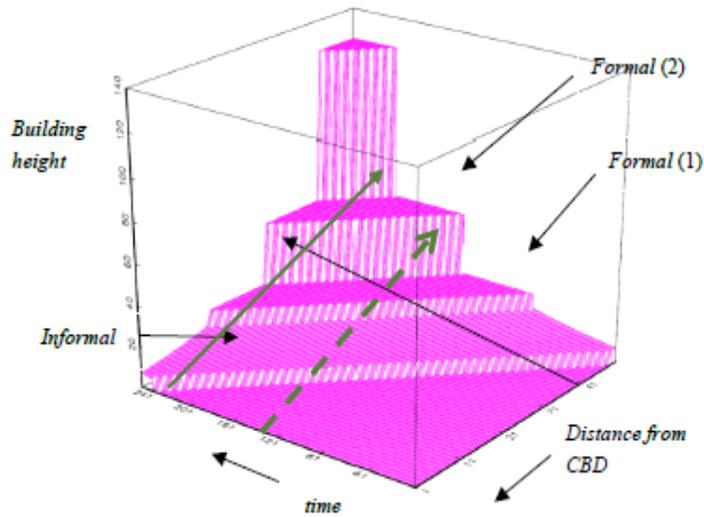
Segment of land with high conversion cost
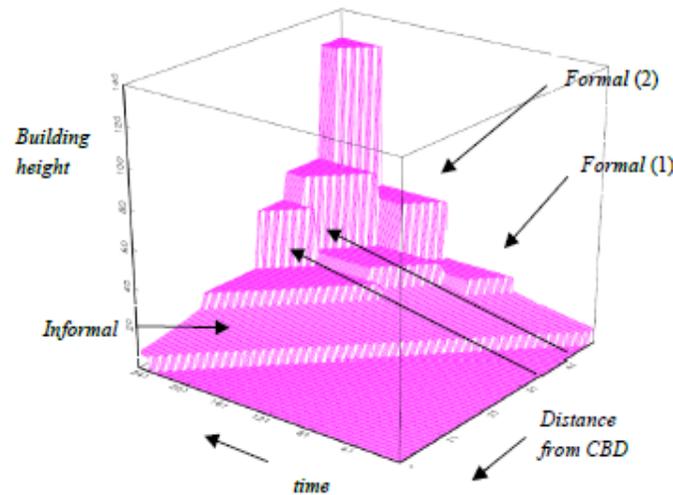
- At a point in time, height rises as move to centre
- At a location height jumps discretely overtime
- If randomly distributed conversion costs over space get a hodgepodge of heights

→ Distance constant

→ Time constant

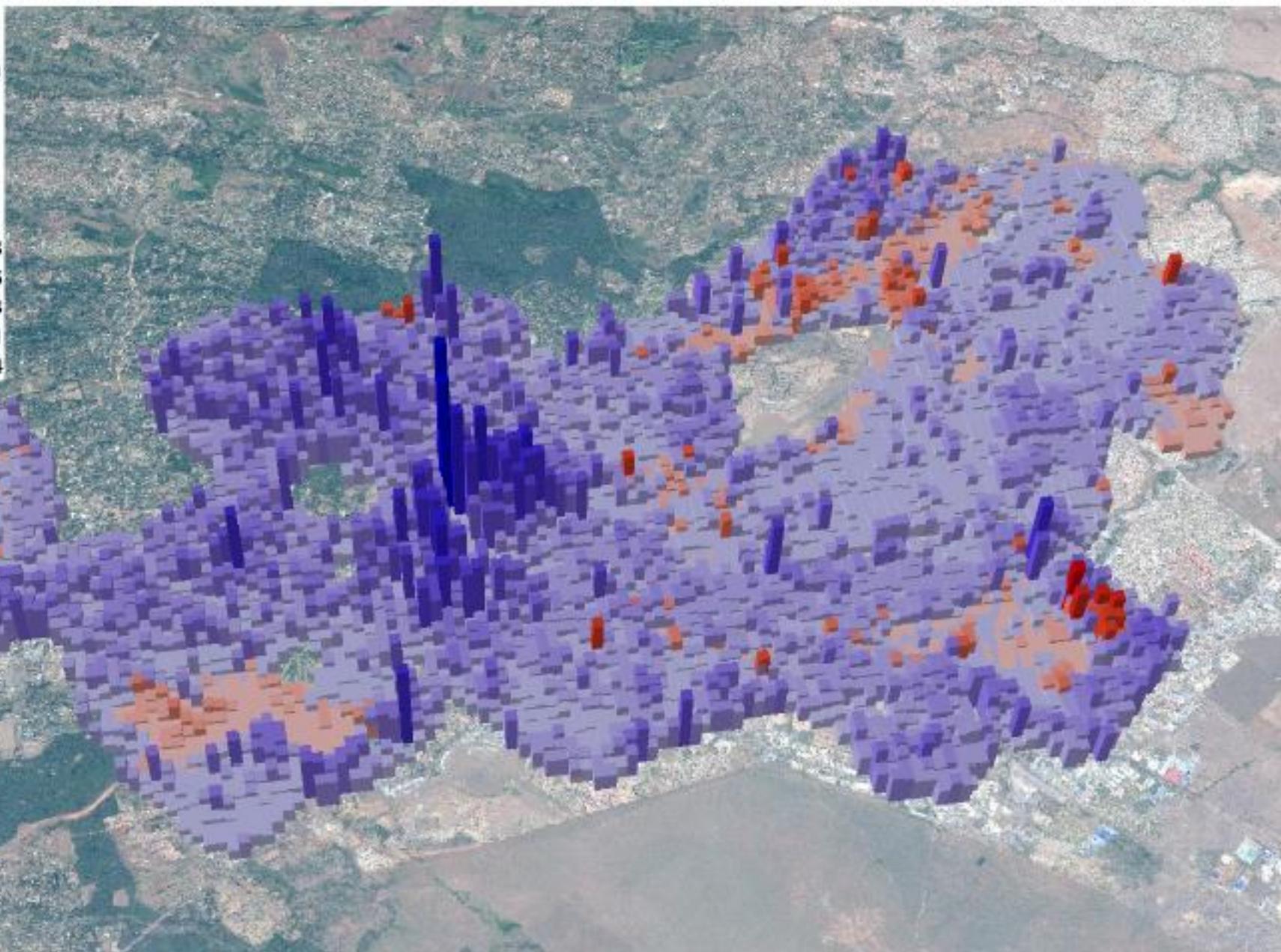## Randomly distributed conversion costs

Empirical work: Nairobi

- Data
  - Built environment data is individual buildings and a grid with thousands of cells (6200 in 2003/4 area), which are 150m by 150m
    - Populated with data on building footprint sizes for 2003/4 and 2015 and heights for 2015
  - The grid is comprised of tracings of aerial photos into building polygons in 2003/4 and 2015. Overlay polygons
  - LiDAR data on heights in 2015
  - Overlay footprint images to define
    - Unchanged buildings
    - Redeveloped buildings (new footprint over old building footprint)
      - Redevelopment is net: new coverage – old coverage
    - Demolished: old building with no new building in old footprint
    - In-fill: new building with no 2004 building in new footprint
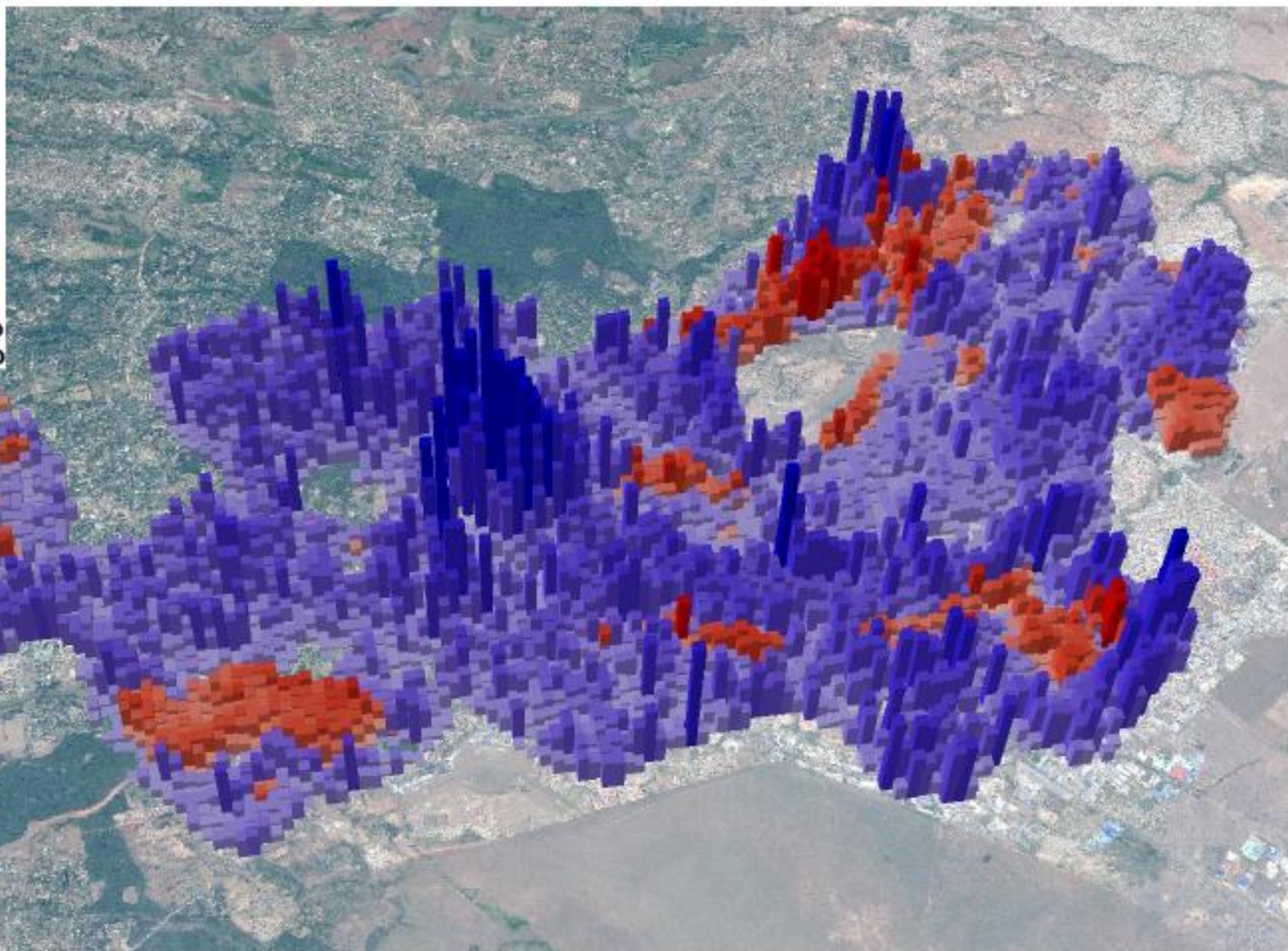
Figure 9 Maps of city height and volume

a.   Height

Legend:

Formal Average Height (m):
- 3 - 6
- 7 - 9
- 10 - 12
- 13 - 16
- 17 - 20
- 21 - 25
- 26 - 32
- 33 - 39
- 40 - 49
- 50 - 69

Slum Average Height (m):
- 3
- 4 - 5
- 6 - 7
- 8 - 9
- 10 - 11
- 12 - 13
- 14 - 15
- 16 - 18
- 19 - 21
- 22 - 24

b. Volume

Formal Volume (1,000 cb-m)
- 0
- <20
- <40
- <50
- <70
- <100
- <130
- <180
- <250
- <500

Slum Volume (1,000 cb-m)
- 0
- <10
- <20
- <30
- <40
- <50
- <60
- <80
- <110
- <160

Land cover per grid square
by use type:
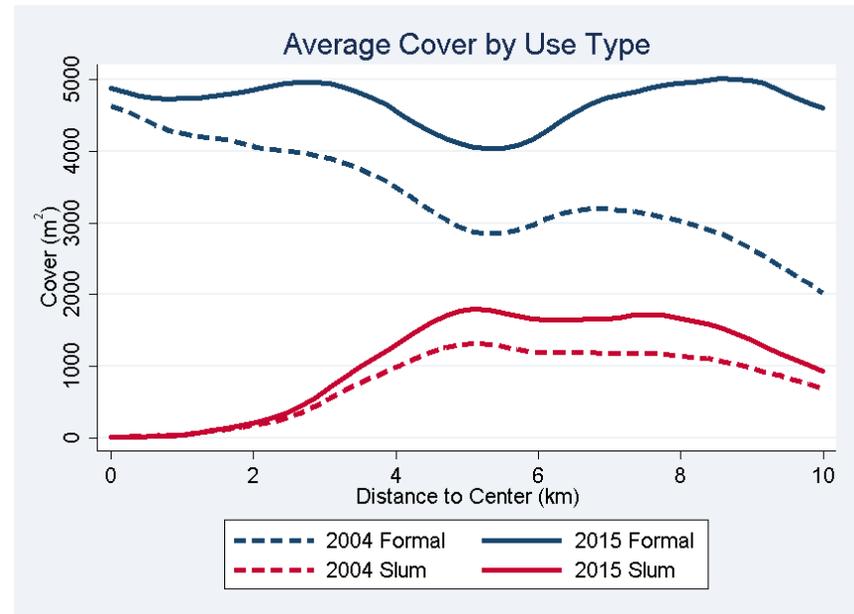
Volume of space per grid
square by use type:

The cost of delayed formalisation?

PV around $4bn (estimate……)
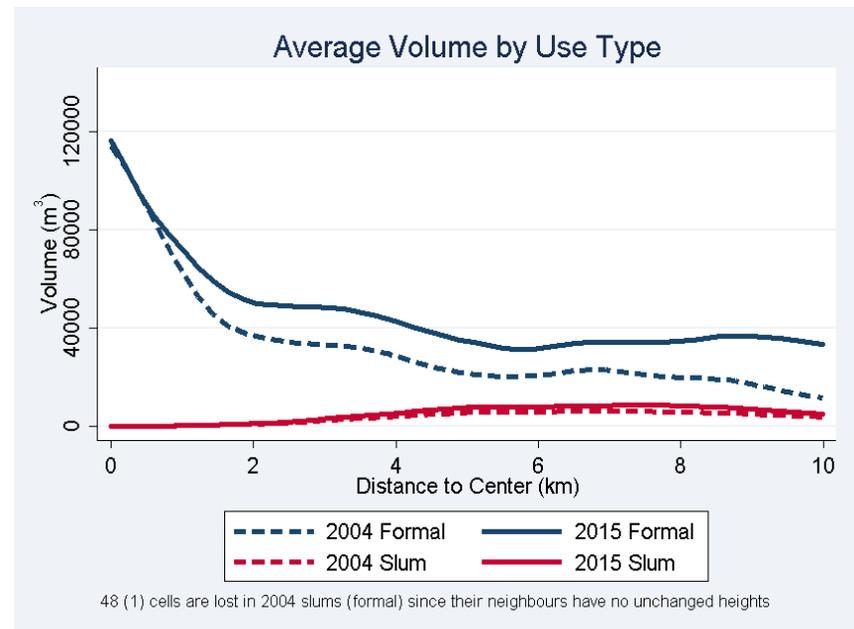
House rents per sq meter square

Rent Gradients

Dashed lines represent 95% confidence bands

The production sector: wages, prices and productivity

The stylised facts:

- African cities have high *nominal* wages….. but also high prices

- African cities have failed to attract 'footloose' internationally tradable activities
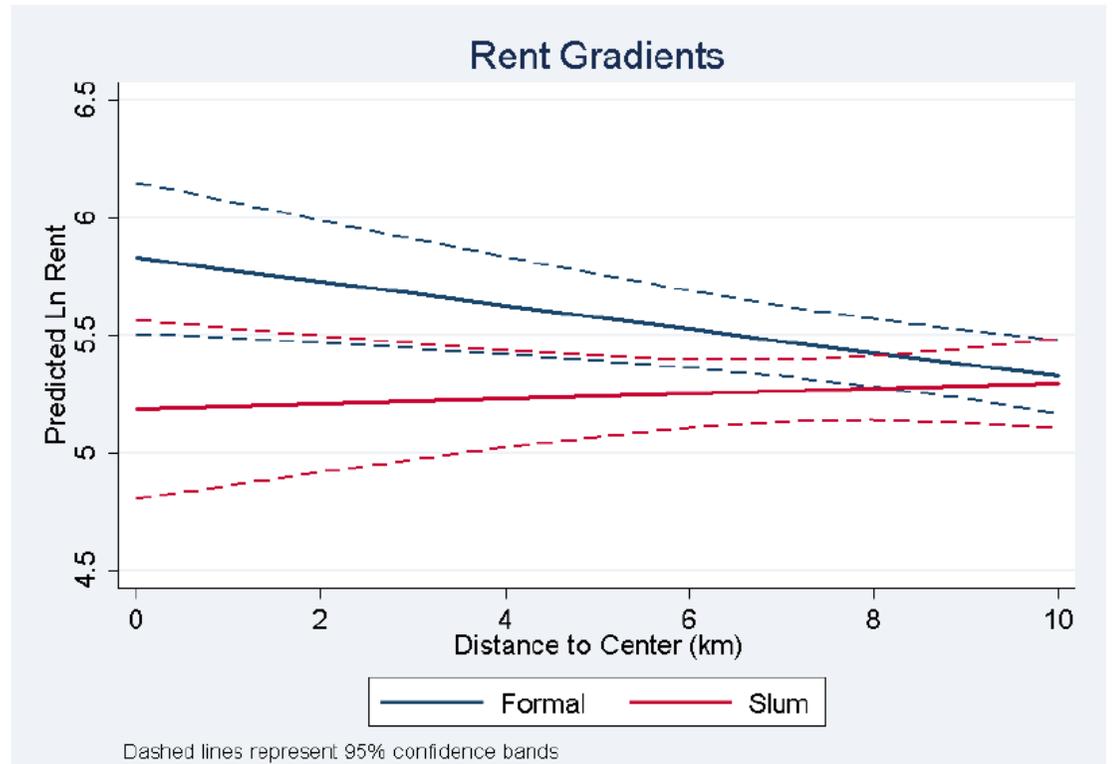
Wages, prices and productivity

The analytical story:

- Labour supply: Inefficient cities → high cost → high nominal wages to compensate

  → low real wages

- Labour demand: High nominal wages supported not by high physical productivity but by high prices of non-tradable goods.

- Implications:

  - Cities too high-cost for inwards investment in tradable goods/ services → unable to break in to tradable sectors

  - If tradables are prone to increasing returns, agglomeration, then:

    - Loss of real income

    - Multiple equilibria and low level trap

    - Reinforced by expectations and building decisions in the city.

Concluding: work in progress

- Most of work described is still in progress

- Other work on project:

    - Within city: still collecting detailed within city data – eg cell phone data

        - Who lives where?

        - Sectoral clustering

        - Labour market

        - Commuting flows

        - Infrastructure improvements

    - Cross-city: patterns of growth in large sample of cities: satellite data