The effects of traffic on firm location
Evidence from the Kampala bypass

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Motivation and research questions

- African cities do not seem to provide the same productivity advantages other cities do.
- This might suggest an inefficient allocation of economic activity, that hinders productivity spillovers.
- We study the location of firms in an African city, and the elasticity of these locations.
- This will help us to gain better understanding of:
  - The effects of urban transport infrastructure on the location of people and businesses.
  - The degree to which businesses and people react to changes of urban fundamentals, and
  - The degree to which policy can help make cities work.
- The ultimate goal of this research is to build a model of the location of firms and people in Kampala, but we are not there yet.
Policy we study

We exploit a large example of urban transport infrastructure investment.

• The Kampala Northern Bypass Highway was built between 2004 and 2009, and opened on October 1st 2009.
• It is 15 kilometers long, and runs around the city of Kampala, on the side away from the lake.
• This bypass road is part of the ‘Northern Corridor’, a principal transport route for East Africa. The bypass is part of the upgrade of that transport route.
• It also had the effect to free Kampala from the heavy traffic around Lake Victoria.
• The 50 million USD to construct the road came from the government of Uganda and the EU.
Hypotheses

We test two sets of hypotheses on the location of firms in Kampala:

1. Firms that rely on trade more (manufacturing) should move towards the highway while firms that rely on trade less (services) move relatively closer to the center. This follows from a model of market access.

2. Following a model of clustering of businesses in cities, we predict that a more efficient transport system should lead to increased clustering of businesses that require more customer interaction relative to other businesses.

(In addition we plan to compare clustering in Uganda to clustering in the UK, and Kampala to Uganda.)
Related literature

• Urban equilibria.
  • Ahlfeldt et al (2015), Berlin paper, urban model and exogeneous shock.
  • Baum-Snow, Brandt, Henderson, Turner, Zhang (2005), ringroads in China.

• Local human capital spillovers

• Methodology of measuring agglomeration economics
  • Duranton and Overman (2005), Combes, Duranton and Gobillon (2010), Combes, Duranton, Gobillon, Roux (2010)
We have access to the following data sources:

- Firm census for 2002 and 2011
- Satellite images by day and night
- Census data
- Household surveys

So far we have mainly exploited the first. We are in contact with the city government of Kampala (Patrick Musoke) and may get infrastructure maps as well as land prices and land regulation.
Data (2)


- Provided by the Uganda Bureau of Statistics, with technical and financial support from DFID, checked and processed by the World Bank.

- Captures the universe of registered firms with a fixed location, down to small firms employing only one person.

- The methodology was to discard all existing databases, and start fresh by walking all the streets of Uganda and recording businesses along the way, recording their coordinates, and going through questionnaires with them.

- After registration, a business got a ‘stick-on label’ on their door. Businesses with no response were revisited.
• In 2011 458,000 businesses were registered, in 2002 160,000.
• In both years around 30 percent of recorded businesses were located in Kampala.
• In 2011 35 percent had 1-4 employees, 13 percent more than 50.
• Similar industry breakdown in each year.
Firms by Industry 2002 and 2011

Data (4)
Firm Locations

Firms, 2002

Firms, 2011

Data (5)
Kernel Density Maps - Clusters of Employment

Employment Centres, Kampala 2002

Employment Centres, Kampala 2011
Hypothesis 1

• Every firm benefits from proximity to the highway, and also from being close to the center.
• Denote $h_i$ the distance to the highway and $c_i$ the distance to the center for firm $i$, then for profit $\Pi_i$, $\partial \Pi_i / \partial h_i < 0$ and $\partial \Pi_i / \partial c_i < 0$. Under a few assumptions, in equilibrium $\partial \Pi_i / \partial h_i = \partial \Pi_i / \partial c_i$.
• A firm for which $|\partial \Pi_i / \partial h_i|$ is larger will locate closer to the highway in equilibrium.
• Manufacturing firms that rely on heavy inputs and international shipments are likely to be among these.
Hypothesis 1

• Conversely firms which rely on proximity to consumers will relatively locate closer to the center.
• There is also pressure for these firms to move towards the highway. There are two effects however that push in the other direction:
  • Manufacturing firms moving out lowers the relative price of being in the center.
  • The Hotelling-style clustering pressure explained later.
• We find evidence for the second.
Regression - firm level weighted by employment

Table: Distance to the Bypass Junctions

<table>
<thead>
<tr>
<th></th>
<th>Distance to nearest Bypass Junction km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>0.148***</td>
</tr>
<tr>
<td></td>
<td>(0.00982)</td>
</tr>
<tr>
<td>Manufacturing 2011 interaction</td>
<td>-0.143***</td>
</tr>
<tr>
<td></td>
<td>(0.0143)</td>
</tr>
<tr>
<td>Sells direct to Consumer</td>
<td>-0.184***</td>
</tr>
<tr>
<td></td>
<td>(0.00783)</td>
</tr>
<tr>
<td>Consumer 2011 interaction</td>
<td>0.160***</td>
</tr>
<tr>
<td></td>
<td>(0.0105)</td>
</tr>
<tr>
<td>Constant</td>
<td>3.747***</td>
</tr>
<tr>
<td></td>
<td>(0.00462)</td>
</tr>
<tr>
<td>2011</td>
<td>0.141***</td>
</tr>
<tr>
<td></td>
<td>(0.00593)</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Shops for consumers in cities cluster to varying degrees.

- Some types of shops tend to spread out evenly over cities
  - Examples are grocery stores, newspaper stands
- Other types of shops tend to cluster within cities.
  - Savile Row London for bespoke tailoring
  - London silver vaults (more than 40 silver shops in one basement)
- Some shops even cluster globally.
  - 85 percent of the world’s diamonds pass through Antwerp.
Why is that? We suggest it could be the consequence of a fundamental trade-off between gains from variety and transport costs.

• Consumers like variety for most types of products, including groceries. For example, in Oxford, Tesco’s and Sainsbury’s cluster at St. Giles.
• Yet clustering increases average transportation costs for the consumers, which in turn decreases total demand for the firms.
• Transportation costs matter more for products that consumers buy at higher frequency, ie. products that are less durable.
• Transportation costs matter less for products that are very expensive.
Model (3)

These effects can be demonstrated in a simple Hotelling model. Assumptions:

- Consumers are uniformly distributed along a line, from 0 to 1.
- Firms produce a product at no cost and charge a fixed price to make one unit of profit per consumer. Firm entry comes at fixed cost $f$. Firms compete solely on location.
- Consumers pay transport costs $td$ to buy from a shop at distance $d$.
- Twist: Consumers get utility $u(n)$ from buying at a location where $n$ firms coincide, where $\partial u / \partial n > 0$. These are gains from variety.
  - Firms no longer want to move a small $\epsilon$ next to an existing cluster of firms.
- Assume that $u(2) < 2u(1)$ and $\partial^2 u(n) / \partial^2 n < 0$. 
Case 1: High transport costs

- One firm locates at $l_1$.
- The triangle shows the utility its customers get, based on their location, which at location $x$ is $\max\{u(1) - t|x - l_1|, 0\}$.
- The intersections show the locations of the marginal consumer, call them $l_1 + d^*$ and $l_1 - d^*$.
- Profits are $2d^*$. 
Model (5)

A second firm has space to copy the first or join the first

- The triangle becomes larger in the second case as $u(2) > u(1)$ at $l_1$. Given $u(2) < 2u(1)$ the second firm prefers the first option.
- Adding firms, they fill up the space spreading evenly. They then co-locate evenly with existing firms.
Model (6)

Case 2: Low transport costs

- Consider the extreme case: Transport costs at $t = \varepsilon$ close 0.
- One firm captures the entire market, irrespective of location.
- With two firms by standard Hotelling argument both co-locate in the centre.
- In fact, $n$ firms co-locating at any point is a Nash equilibrium for any $n > 2$. 
Case 2: Low transport costs, but not in the limit.

- Two firms cluster in the centre, by Hotelling result.
- There is a Nash equilibrium with everyone in the center for large $n$ (deviations become unprofitable - it is more profitable to join the centre than to move to the point where $u(1) > u(n - 1)$).
Lessons:

• The higher transport costs, the less frequent are Nash equilibria involving clusters for a given number of firms $n$.
• This even holds for small ‘gains from variety’.
• Surprisingly different results to standard Hotelling from making a small change of assumptions.

Of course similar predictions can be the result of many other models.
The main aim of the bypass was to remove traffic from the roads of Kampala.

- This has a direct beneficial effect of reducing transport times (in the short run).
- Given this model it might have the additional benefit of leading to a more efficient location of industry.
- The benefits may then be due to gains from variety to consumers (and other local spillover effects we are aware of but do not discuss here).
- Testable hypothesis: The bypass will lead to increased clustering of consumer shops, especially for products that are durable and/or relatively expensive.
How to measure clustering

• Aggregation based measures (Ellison and Glaeser 1997)
  • We have few observations in many industries, and small distances matter here.
  • Ambiguity of aggregation.

• Ripley K and L functions
  • Roughly count number of other firms within radius $x$. Closely related to what we use.
  • Does not involve the smoothing we need to compare industries with very different distances.
  • Counterfactuals based on Poison processes not reliable here given unevenness of firm clustering.
How to measure clustering

We follow Duranton and Overman (2005)

• Provide a measure that is comparable across industries, controls for the overall agglomeration, controls for industrial concentration, is unbiased with respect to scale and gives an indication of significance of the result.

• Measure based on the distribution of pairwise distances.

• Compare distance distribution to distribution obtained from randomly allocating firms of industry $i$ to locations from all industries.

• Works on the basis of individual firms, which allows us to use more data than density alternatives such as Ellison and Glaeser (1997).

• For now we focus on industries with at least ten firms in both years. The industry classification in our data changed between the two years, but 42 industries have identical names. We focus on these.
Measure clustering

Example 1: Technical and vocational secondary training.
Measure clustering

Example 2: Market research (not clustered).
Measure clustering

Example 3: Wholesaling of agricultural raw materials and live animals (strongly clustered).
Most and least clustered 2002

Measured as $\Gamma_{2002}$ - global clustering:

- **Most clustered:**
  - Legal activities
  - Accounting, bookkeeping and auditing activities
  - Wholesale of agricultural raw materials and live animals
  - Non life insurance
  - Other monetary intermediation

- **Least clustered (all 0):**
  - Cargo handling
  - Hospital activities
  - Manufacture of plastic products
  - Manufacture of soap and detergents
  - Market research
Most clustered 2011

Measured as $\Gamma_{2011}$ - global clustering:

- **Most clustered:**
  - Wholesale of textiles, clothing and footwear
  - Printing
  - Legal activities
  - Service activities related to printing
  - Quarrying of stone, sand and clay

- **Least clustered:**
  - Advertising
  - Reproduction of recorded media
  - Manufacture of plastic products
  - Manufacture of soap and detergents
  - Market research
Industries that cluster more

Measured as $\text{rank}(\Gamma_{2011}) - \text{rank}(\Gamma_{2002})$

- More clustering after bypass construction
  - Higher education
  - Research and experimental development on natural sciences and humanities
  - Non-life insurance
  - Other monetary intermediaries
  - Real estate

- Less clustering after bypass construction
  - Sawmilling and planning of wood
  - Manufacture of malt liquors and malt
  - Maintenance and repair of motor vehicles
  - Distilling, rectifying and blending of spirits
  - Washing and cleaning of textile and fur products
Do manufacturing firms cluster less?

- Regressions of trends show expected signs, but are not significant. Larger sample might show this trend significantly:
  - Manufacturing is less clustered in both years
  - Manufacturing clusters relatively less after the bypass (d-i-d)
  - Opposite trends for consumer products
- See for example:

\[
\ln(rank_{11}) - \ln(rank_{02}) = \hat{\alpha} - 0.558(0.282)\text{\ manufacturing}
\]

- (The p-value of this is 0.057).
Conclusions

- We evaluate the effects of improved urban transport infrastructure.
- Urban location of firms responds to the environment in which they operate.
- Firms in non-manufacturing sectors cluster more in response, as predicted by theory.
- Manufacturing moves closer to the bypass, while consumer services move away from it.