# Consumer Search and Firm Location: Theory and Evidence from the Garment Sector in Uganda

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# Motivation

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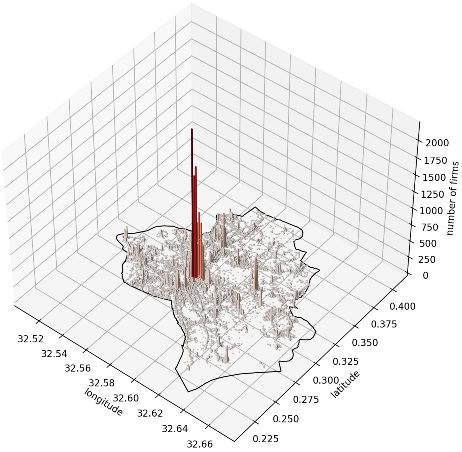

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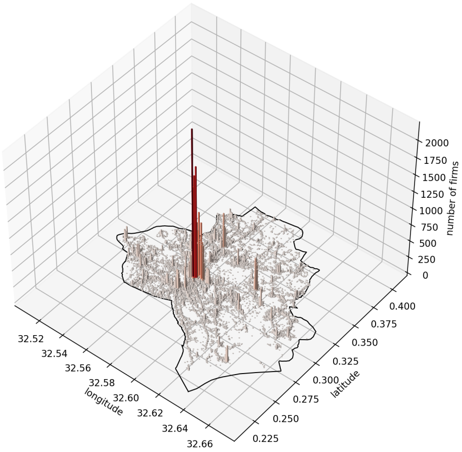


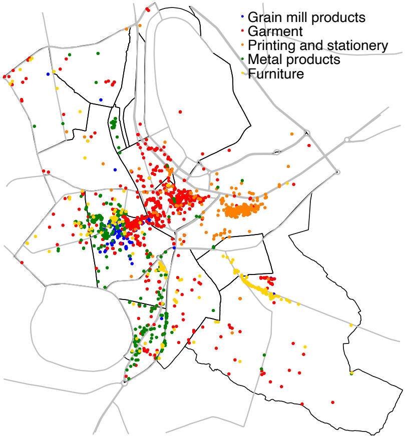


**Source**: 2010 Ugandan Census of business establishments

New York

# Motivation: what drives firms' spatial concentration?

- Quantitative spatial models: focus on *production externalities* (Ahlfeldt et al., 2015; Allen, et al., 2015; Monte et al., 2018; Owens et al., 2020)
- This paper: theory and data to quantify role of *consumers' information frictions*
  - Agglomerated firms attract consumers by lowering cost of gathering information
  - More firms to compete with, but larger customer base (Stahl, 1982; Wolinski, 1983)

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  - More firms to compete with, but larger customer base (Stahl, 1982; Wolinski, 1983)
- Salient in low-income settings: (i) in person search, (ii) bundling of production and sale
- Why does it matter?
  - Different welfare implications of urban / spatial policies
  - Consequences of demand-side constraints for misallocation

# This paper

**Information frictions $\rightarrow$ Consumer search $\rightarrow$ Firm location $\rightarrow$ Welfare**

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**Information frictions → Consumer search → Firm location → Welfare**

- **Data**: Collect data from garment firms and customers in Kampala
  1. *Transaction data*: estimate demand
  2. *Customer data*: evidence on search
  3. *Mystery shoppers data*: quality and prices

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- **Model**: Quantitative equilibrium model of consumer search and firm location
  - *Agglomeration*: information frictions, proximity to suppliers
  - *Congestion*: within-location competition, transport costs, factor prices
- **Counterfactuals**:
  - Equilibrium outcomes in the absence of information frictions
  - Assess welfare effects of policies on Ugandan policymakers' agenda
    - E-commerce
    - Decongestion policies

# Preview of findings

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   - When removed: $\uparrow$ profits of high quality, $\downarrow$ profits of low-quality firms
   - 37% of low-quality firms make losses and are better off exiting the market
3. **Opposite effects of policies that target cause vs. symptoms of the inefficiency**
   - E-commerce: 83% drop in sales in the core, primarily *benefits* high-quality firms
   - Decongestion policies: disproportionately *harm* high-quality firms

# Literature

1. **Quantitative spatial models of city structure**
   - Role of production externalities (Ahlfeldt et al., 2015; Allen, et al., 2017; Monte et al., 2018; Davis et al., 2019; Agarwal et al., 2020; Owens et al., 2020; Miyauchi et al., 2021)
   - *Contribution*: additional role of information frictions
2. **Consumer search**
   - Impact on price elasticity and mark-ups (Hortaçsu and Syverson, 2004; Hong and Shum, 2006; De Los Santos et al., 2012; Murry and Zhou, 2020; Moraga-Gonzàlez et al., 2022)
   - *Contribution*: endogenize firm location
3. **Information frictions and trade flows**
   - Excessive price dispersion, survival of low-productivity firms (Arkolakis, 2010; Allen, 2014; Steinwender, 2018; Startz, 2021; Jensen, 2007; Aker, 2010; Goyal, 2010; Atkin et al., 2017; Jensen et al., 2018)
   - *Contribution*: demand-driven agglomeration to infer information frictions within a city

# Outline

1. Setting and data
2. Motivating facts
3. Model
4. Estimation and counterfactuals
5. Conclusions

# 1. Setting and data

# Kampala Garment sector

- Kampala: capital and economic hub of Uganda (60% of GDP)
- Garment sector: 42% of manufacturing firms, 15% of employment
- Median firm: Descriptives
  - 1 worker, 3 machines, 3 $m^2$ surface, 93% informal
  - 5 years old, $100 revenues per month
- Hybrid between manufacturers and retailers
  - Production and sale done by the same person, in the same location

# Data

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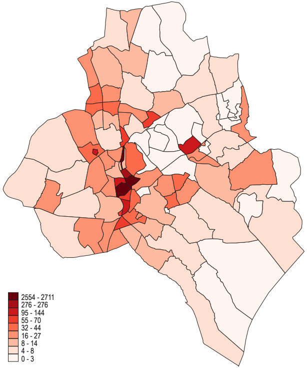
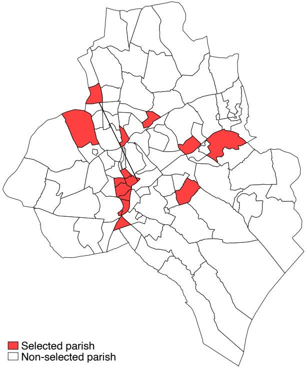



Panel A: Firms per square-km




Panel B: Selected Parishes

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2. Survey of 600 randomly selected firms (50% in Core, 50% in Periphery)
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    - Way in which consumers search for firms
4. Mystery shoppers exercise
    - Same garment commissioned to all firms
    - Quality assessment by expert tailor Mystery Details

# 2. Motivating Facts

# Motivating Facts

- *How do consumers search?*
  1. **Pay large transport costs to travel to the core, but visit more firms prior to purchasing**
     - Average transport cost to core vs. periphery: \$1.28 vs. \$0.48, 34 vs. 17 minutes
     - In core, visit 22% more firms before purchasing Fact 1

# Motivating Facts

- *How do consumers search?*
  1. Pay large transport costs to travel to the core, but visit more firms prior to purchasing
  2. **Customers visit the core to find more varieties and higher quality products**
     - Main reason for searching *Periphery*: proximity to home (64%)
     - Main reason for searching *Core*: number of tailors/varieties (55%), high-quality (58%) Fact 2

# Motivating Facts

- *How do consumers search?*
  1. Pay large transport costs to travel to the core, but visit more firms prior to purchasing
  2. Customers visit the core to find more varieties and higher quality products
- *How do firms choose location?*
  3. **Firms in the core serve fewer, but larger customers, who grant them larger revenues**
     - On average, firms in the core serve 18% fewer customes, but make 1.3 times the revenues of firms in periphery Fact 3

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  3. Firms in the core serve fewer, but larger customers, who grant them larger revenues
  4. **Are more likely to outsource intermediate tasks to nearby suppliers**
     - In core, 41% of workers involved in production are external (vs. 32% in periphery)
     - Average distance to suppliers substantially lower in core (95% within 5 minutes walking) Fact 4

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  3. Firms in the core serve fewer, but larger customers, who grant them larger revenues
  4. Are more likely to outsource intermediate tasks to nearby suppliers
- Suggest: (i) consumers are affected by search frictions; (ii) firms internalize frictions in their choice of location
- Develop an equilibrium model to **quantify** the importance of this channel

# Key features of the model

1. **Demand**:
   - **A1**: Consumers must pay *fixed* transport cost to the firm to observe preference over varieties
   - **A2**: Once in a location, observe preferences over all varieties sold in the location

     → All else equal, consumers prefer to search in locations with a high concentration of firms

     → Agglomeration stronger for large buyers due to *economies of scale in transport*

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3. **Congestion**:
   - **A4**: Fiercer within-location *competition*, higher *commuting costs* and *factor prices* in high-density locations Rent

# 3. Model

# Set-up

**Supply**

- Finite number of firms $J$
  - Single-product, horizontally and vertically differentiated Varieties
  - Owned by individuals exogenously distributed across locations $I = \{1, 2, ..., N\}$
  - Idiosyncratic preferences over locations

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  - Idiosyncratic preferences over locations
- They choose:
  1. Where to locate
  2. Once in a location, what price to charge
  3. What combination of land, internal and outsourced labor to employ

# Set-up

**Demand**

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  - Purchase one type of good, but heterogeneous in quantity $q$ demanded of a given good
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**Static model**: formation of firm-customer matches and location choices that persist over time

# Model overview

1. Demand:
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    - Which firm to buy from
2. Supply:
    - Production and outsourcing
    - Price choice
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# Consumer utility

- Utility of consumer $i$ buying product $j$ in location $l$ is:

$$u_{ijl}^{q} = \left(\beta \mathbf{x}_j + \xi_j + (1-\sigma)\varepsilon_{ij}\right) q^{\theta} - \alpha p_{jl} q - C_{il}$$

- $\mathbf{x}_j$, $\xi_j$: observable and unobservable product **quality**
  - *Vertical differentiation*: same ranking for all consumers
- $\varepsilon_{ij}$: idiosyncratic **taste** shock, iid $\sim$ standard T1EV
  - *Horizontal differentiation*: match specific (e.g. preference for style, color, fit, cut)
- $p_{jl}$, $q$: product $j$ price and quantity bought by individual $i$
- $C_{il}$: search cost

# Search cost

$$C_{il} = \tau_1 g(||z_i - z_l||) + \tau_2 \frac{N_l}{ar_l} + \omega_{il}$$

- $||z_i - z_l||$: distance between consumer and firm location
  - Transport cost to location
- $\frac{N_l}{ar_l}$: number of firms per square-km
  - Firm-specific search cost
- $\omega_{il}$: individual-location specific search cost, iid $\sim$ standard T1EV
  - E.g. idiosyncratic information

# Timing of Consumer decision

1. Before searching, consumers **do not observe** $\varepsilon_{ij}$
2. Choose **location** based on available information

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1. Before searching, consumers **do not observe** $\varepsilon_{ij}$
2. Choose **location** based on available information
3. Upon paying the **search cost**, observe $\varepsilon_{ij}$ for all firms in the selected location
4. Choose **firm** that yields the highest utility

Scores Corr

# How does the number of firms affect demand?

1. **Market-size effect**: attracts consumers by increasing the number of available varieties

   - Let $s_{il}$ be the share of customers of type $i$ buying in location $l$

$$s_{il}^{q}(\mathbf{L},\mathbf{p}) = \frac{\left(\sum_{j=1}^{N_l} \exp\left(\frac{\delta_{jl}^{q}}{1-\sigma}\right)\right)^{q^{\theta}(1-\sigma)} \exp(-C_{il})}{\sum_{k=0}^{N}\left[\left(\sum_{h=1}^{N_h} \exp\left(\frac{\delta_{hk}^{q}}{1-\sigma}\right)\right)^{q^{\theta}(1-\sigma)} \exp(-C_{ik})\right]}$$

- All else equal, location share is increasing in $N_l$
  - Observe more $\varepsilon$ draws (more varieties)
  - Higher probability of finding product with desired characteristics

Location Utility

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- All else equal, location share is increasing in $N_l$
- Effect is increasing in $q$
  - Large consumers benefit from a better match over all units of products bought

Location Utility

# How does the number of firms affect demand?

1. Market-size effect: attracts consumers by increasing the number of available varieties
2. **Market-share effect**: increases competition within a location
   - Let $s_{j|l}$ be the share of customers of type $i$ buying from firm $j$ conditional location $l$

$$s^q_{j|l}(\mathbf{p}_l) = \frac{\exp\left(\frac{\delta^q_{jl}}{1-\sigma}\right)}{\sum_{h=1}^{N_l} \exp\left(\frac{\delta^q_{hl}}{1-\sigma}\right)}$$

- All else equal, conditional firm share is decreasing in $N_l$

# Unconditional demand and sorting

**Unconditional demand**: $s^q_{ijl}(\mathbf{L},\mathbf{p}) = s^q_{il}(\mathbf{L},\mathbf{p}) \times s^q_{j|l}(\mathbf{p}_l)$

- Two opposite effects of number of firms $N_l$:
  1. *Market-size effect*: $\uparrow s^q_{il}$
  2. *Market-share effect*: $\downarrow s^q_{j|l}$
- Marginal effect depends on relative strength of these two forces

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**Sorting:** In absolute value, $\frac{S_{ijl}}{N_l}$ larger for high-quality firms

- If positive, high-quality firms sort into larger locations
- Intuition: all firms equally benefit from market-size, but high-quality firms less affected by market-share effect

Sorting | Aggregate Demand | Production | Pricing

# Model overview

1. Demand:
   - Where to search
   - Which firm to buy from
2. Supply:
   - Production and outsourcing
   - Price choice
3. **Firm location choice**

# Firm location choice

- Static game of incomplete information
- Given spatial distribution of other firms ($\mathbf{L}$), firm $j$'s profits in $l$ are:

$$\Pi_{jl}(\mathbf{L}, \mathbf{p}) = \pi_{jl}(\mathbf{L}, \mathbf{p}) - FC_{jl}$$

- **Variable profits**: $\pi_{jl}(\mathbf{L}, \mathbf{p}) = (p_{jl} - c_{jl})Q_{jl}(\mathbf{L}, \mathbf{p})$
- **Fixed cost**: $FC_{jl} = \tau_3 g(||z_j - z_l||) + e_{jl}$
  - $||z_j - z_l||$: distance between the owner's home and the firm location
  - $e_{jl}$: idiosyncratic preference shock, *unobserved* by other firms, iid $\sim$ T1EV

# Consumption and production externalities

- **Variable profits**: $\pi_{jl}(\mathbf{L},\mathbf{p}) = (p_{jl} - c_{jl})Q_{jl}(\mathbf{L},\mathbf{p})$

$$\frac{d\pi_{jl}(\mathbf{L},\mathbf{p})}{dN_l} = \underbrace{(p_{jl} - c_{jl})\frac{\partial Q_{jl}(\mathbf{L},\mathbf{p})}{\partial N_l}}_{\text{consumption externality}} - \underbrace{\frac{\partial c_{jl}}{\partial N_l}Q_{jl}(\mathbf{L},\mathbf{p})}_{\text{production externality}} + \frac{\partial p_{jl}}{\partial N_l}Q_{jl}(\mathbf{L},\mathbf{p})$$

  - $\frac{\partial Q_{jl}(\mathbf{L},\mathbf{p})}{\partial N_l} > 0$: if *market-size* effect dominates *market-share* effect, demand increasing in $N_l$
  - $\frac{\partial c_{jl}}{\partial N_l} < 0$: cost of outsourcing is lower in high $N_l$ locations (but land prices and wages higher)
  - Impacts might be mitigated or enhanced by effect on equilibrium prices

Equilibrium

# 4. Estimation and Counterfactuals

# Bringing the model to the data

- CONSUMERS: Two types - **Final, retailers**
  - Final consumers buy one unit of output
  - Retailers buy ten units of output (median transaction size in data)

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- LOCATION: Restrict firm choice to
  - Parish where owner lives
  - Core of the city

# Roadmap for estimation procedure

1. **Demand**: $\{\alpha, \beta, \sigma, \theta, \tau_1, \tau_2\}$
   - Data: transaction and mystery shoppers (price and quality)
   - Method: maximum likelihood Demand Details
2. **Supply**: $\{\delta, A_l, T(N_l)\}$
   - Data: firm survey (choice of land and labor, wages, rents)
   - Method: simulated method of moments Supply Details
3. **Location**: $\{\tau_3\}$
   - Data: firm survey (firm location and owner's origin)
   - Method: Nested Fixed Point Algorithm (Rust 1987) Location Details

# Overview of counterfactuals

**1. Shutting down information frictions**

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    - Can get products delivered at a flat fee
3. **Decongestion policies**
    - Cap the number of firms allowed to operate in the core
    - Motor-cycle taxis ban in the core

# Counterfactual 1: Shutting down information frictions

| | **Baseline** | **No information frictions** |
|---|---|---|
| Share of firms in core | 0.365 | 0.335<br>**-8.2%** |
| Share of sales in core | 0.382 | 0.222<br>**-42%** |
| Average price | 20.44 | 17.52<br>**-14%** |
| Average profits | 476.0 | 391.0<br>**-18%** |
| Average consumer welfare | 19.22 | 21.31<br>**+11%** |

Parameters Model Fit

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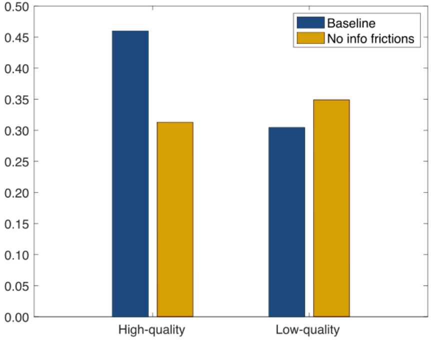
# Counterfactuals 1: High vs. low-quality firms

Panel A: Share of firms in core



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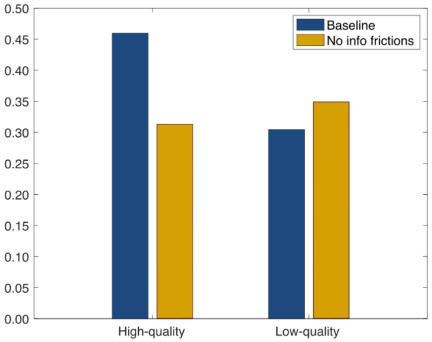
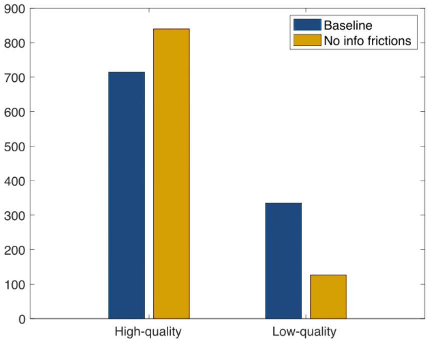



Panel B: Firm profits



# Counterfactuals 2 & 3: E-commerce and caps

- In Kampala, travel time estimated to be 13.5% of the city GDP (+4.2% with congestion) (Baertsch 2020)
- Simulate the impact of two policies on the agenda:
  1. E-commerce platform: no information frictions, flat delivery fee
  2. Cap number of owners that can operate in the core

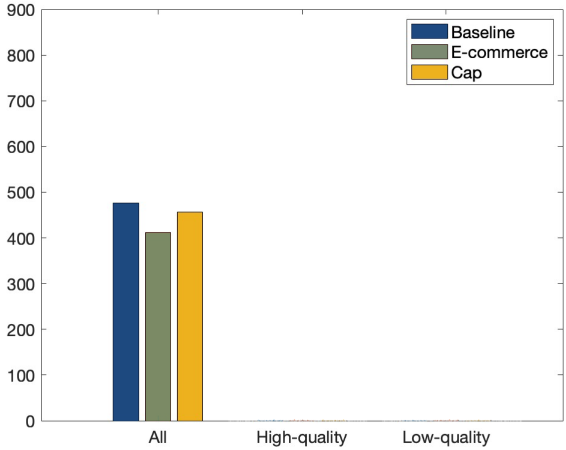

**KCCA removes mobile money kiosks off Kampala streets**

The Independent · January 18, 2022 · NEWS · 4 Comments


*KCCA officers remove a kiosk from Burton street in Kampala. URN photo*

# E-commerce vs. caps on high and low-quality firms

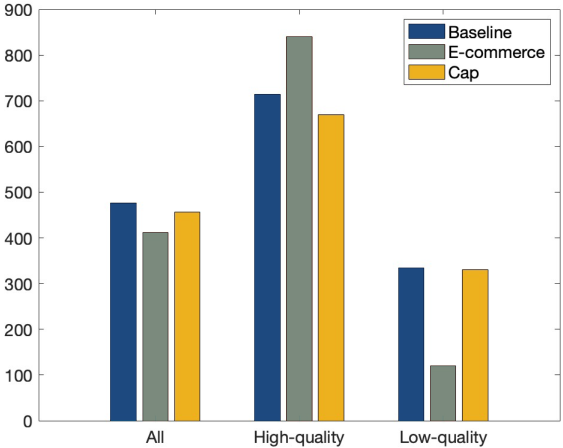
- Compare effect on **profits** of e-commerce and caps that induce same spatial dispersion




E-Commerce Caps Boda Ban

# E-commerce vs. caps on high and low-quality firms

- Compare effect on **profits** of e-commerce and caps that induce same spatial dispersion




ECommerce Caps Boda Ban

# Conclusions

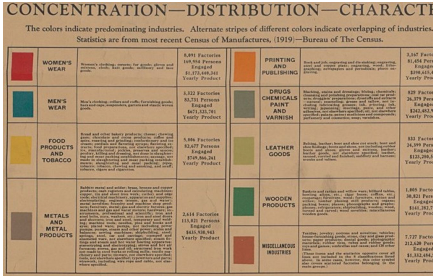
- Case study that highlights the importance of information frictions for firms' location choice
- Framework extends to contexts with information frictions and costly search:
  - Low and high-income settings in which search is conducted in person
  - But might also contribute to concentration of sellers on online platforms

# Conclusions

- Case study that highlights the importance of information frictions for firms' location choice
- Framework extends to contexts with information frictions and costly search:
  - Low and high-income settings in which search is conducted in person
  - But might also contribute to concentration of sellers on online platforms
- Broader implications:
  1. Information frictions limit the ability of high-quality firms to attract customers
     $\rightarrow$ Role in explaining *slow growth* and *firm size distribution*
  2. Firms rely on networks to achieve scale via outsourcing and machines rental (Bassi et al. 2022)
     $\rightarrow$ Within-firm contracting frictions preventing firms from *merging/integrating*

# Appendix

# 1919 New York


**Source**: 1919 US Census of Manufacturers

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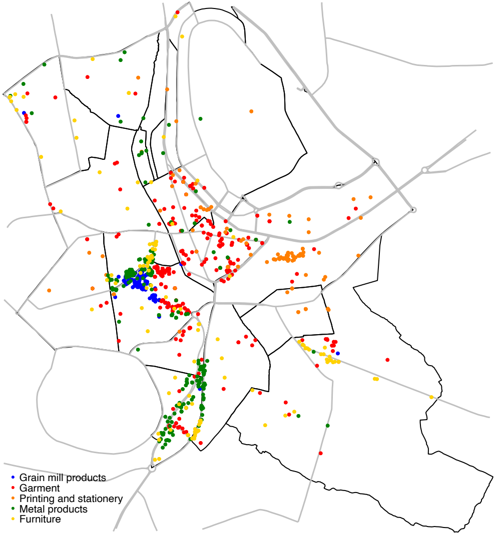
# Manufacturing Firms, 2002 Census




Source: 2002 Census of Business Establishments

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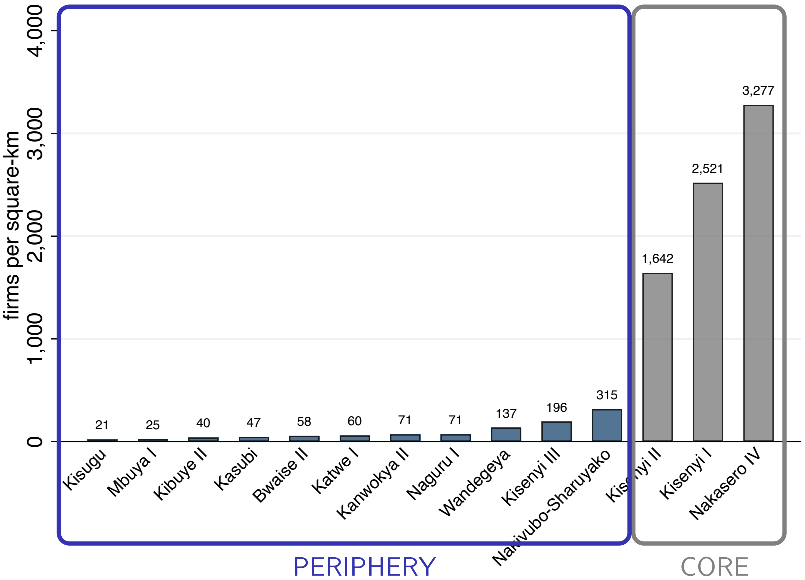
# Firm Density in Selected Parishes

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# Firm Descriptives

| | All | Core | Periphery | P-value |
|---|---|---|---|---|
| Number of workers | 1.319 | 1.250 | 1.701 | {.000} |
| | [1.000] | | | |
| Number of machines | 3.674 | 3.573 | 4.224 | {.002} |
| | [3.000] | | | |
| Size of premises ($m^2$) | 3.005 | 2.652 | 4.952 | {.000} |
| | [2.000] | | | |
| Years of operation | 8.001 | 7.974 | 8.151 | {.814} |
| | [5.000] | | | |
| Monthly revenues (USD) | 167.039 | 179.402 | 100.611 | {.000} |
| | [100.442] | | | |
| Rent per square-meter (USD) | 19.459 | 20.847 | 11.717 | {.000} |
| | [14.147] | | | |
| Monthly commuting cost (USD) | 36.642 | 39.817 | 19.564 | {.000} |
| | [40.743] | | | |
| Number of observations | 601 | 302 | 299 | |

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# Mystery shoppers design and scoring

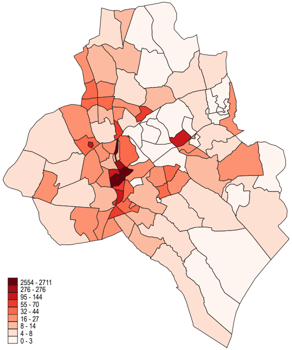
| BUSINESS ID: | | | | |
|---|---|---|---|---|
| | ASSESMENT CRITERIA | SCORING GUIDE | MAX SCORE | SCORE |
| 1 | DARTS | Dart of 4 ”long by 1”wide | 3 | |
| | | Correctly sewn | 3 | |
| | | Press to the right side | 2 | |
| | | Position of the Dart observed | 2 | |
| 2 | COLLAR | Peter Pan/Baby Collar | 5 | |
| | | Fixed correctly round the neckline | 5 | |
| 3 | SLEEVES | Sleeved Well Gathered | 3 | |
| | | Sleeve Length 8” | 2 | |
| | | Round sleeve 14” | 2 | |
| | | Correctly fixed on Bodice | 3 | |
| 4 | SKIRT | Skirt length 18” | 2 | |
| | | Skirt Equally Gathered | 2 | |
| | | Neatly fixed to Bodice | 2 | |
| | | Correct Seam Allowance | 2 | |
| | | Skirt bottom shaped round | 2 | |
| 5 | ZIP | Zip attached to Centre back seam | 4 | |
| | | Right color of Zip | 3 | |
| | | Right length of Zip | 3 | |
| 6 | SEAM | Right Seam Allowance “Y2-1” | 3 | |
| | | Correctly Pressed | 3 | |
| | | Neatly Finished Edges | 4 | |
| 7 | HEM | Hemmed bottom of Dress | 2 | |
| | | Hem lin-2ins | 1 | |
| | | Hem Neatly sewn | 3 | |
| | | Hem well pressed | 4 | |

Back

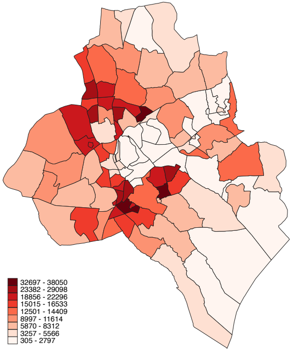
# 1. Firms and customers pay high transport costs to the Core

- Transport cost to Core: 22% of firms' daily revenues, 14% of transaction value
  - More than twice the cost to travel to Periphery
- In the Core, customers visit 22% more firms prior to purchasing

**PANEL A: Firms per square-km**




**PANEL B: Residents per square-km**

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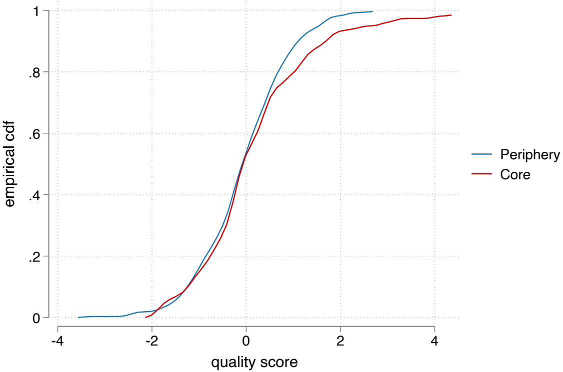
# 2. Firms in the core sell higher quality products on average

- On average, firms in core are of higher quality (p-value = 0.039)
- Difference driven by tails, suggesting the best firms select into the core (Combes et al. 2012)

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# Customers' reasons for *searching* in Core vs. Periphery


Appendix

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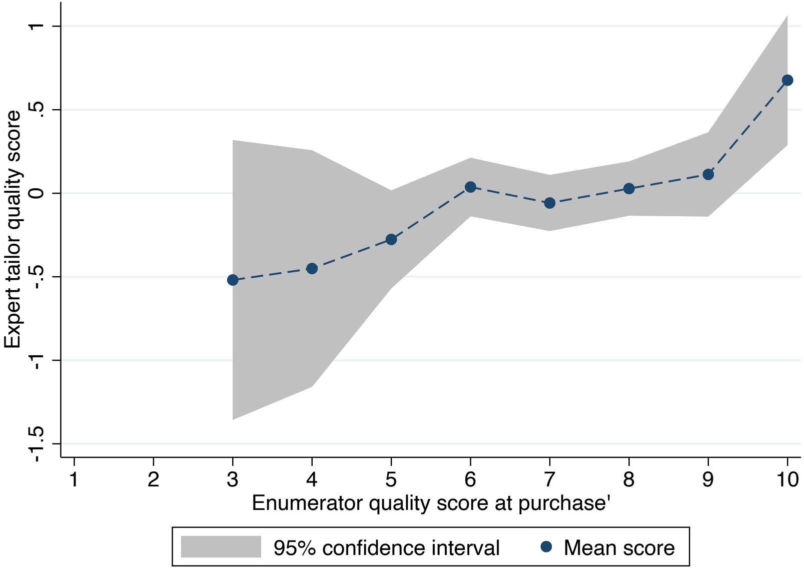
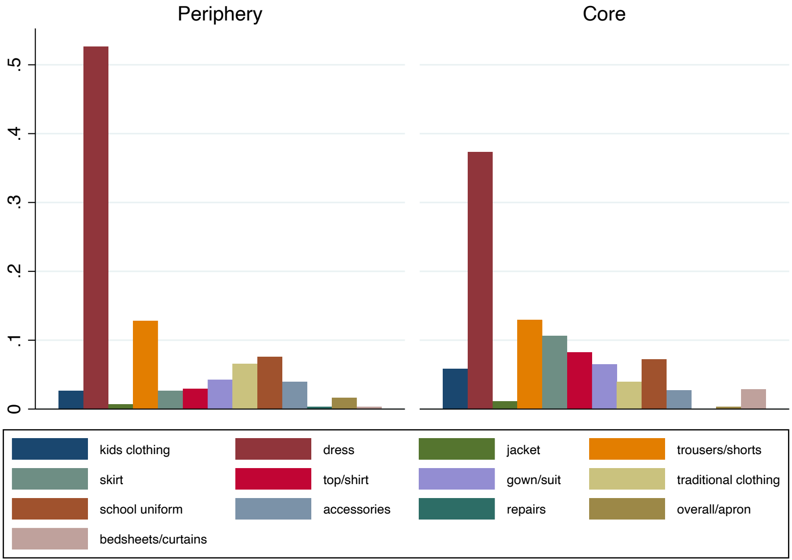
# Correlation between enumerators' and expert tailor's scores



# Product variety across locations

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# Typical dress

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# Way in which customers would search for firms

| | % of final customers | % of retail customers |
|---|---|---|
| Walk into any firm | 53.5 | 55.8 |
| Ask friends/family members | 43.9 | 42.4 |
| Ask other tailoring firm | 14.5 | 33.8 |
| Ask firm in different sector | 6.9 | 11.9 |
| Look on the internet | 7.9 | 4.0 |

**Note:** Data is from the baseline of customers.

Back

# 3. Firms in Core serve fewer customers, but a larger share of retailers

| | (1) Daily customers | (2) Daily revenues (USD) | (3) Share of retailers | (4) Transaction Value (USD) | (5) Quantity | (6) Unit price (USD) |
|---|---|---|---|---|---|---|
| Core | -0.163** | 9.336*** | 0.446*** | 4.289*** | 14.35*** | -0.215 |
| | (0.0799) | (2.340) | (0.0294) | (0.923) | (1.493) | (0.243) |
| Quality score | | | | 1.489*** | -1.936** | 0.836*** |
| | | | | (0.571) | (0.781) | (0.183) |
| Mean \| Periphery | 0.980 | 7.423 | 0.102 | 6.763 | 3.628 | 3.136 |
| Product FEs | | | | ✓ | ✓ | ✓ |
| N. Observations | 546 | 546 | 512 | 2726 | 2726 | 2726 |

**Note**: Data is from transactions records and mystery shoppers. In Columns 1 to 3, the unit of observation is the firm. In Columns 4 to 6, it is the transaction. Standard errors in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

Back

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| Product FEs | | | | ✓ | ✓ | ✓ |
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**Note**: Data is from transactions records and mystery shoppers. In Columns 1 to 3, the unit of observation is the firm. In Columns 4 to 6, it is the transaction. Standard errors in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

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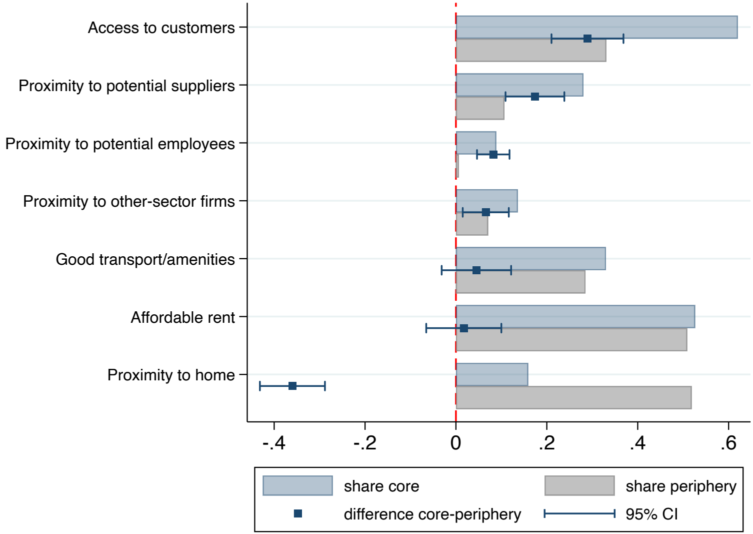
# Firms' reasons for *locating* in Core vs. Periphery?

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# Firm relocation

| | % of firms |
|---|---|
| **No Relocation** | |
| never relocated | 54.4 |
| **Relocation to Core** | |
| periphery to core | 5.32 |
| outside Kampala to core | 6.16 |
| relocated within core | 11.3 |
| **Relocation to Periphery** | |
| core to periphery | 2.83 |
| outside Kampala to periphery | 7.82 |
| relocated within periphery | 12.1 |

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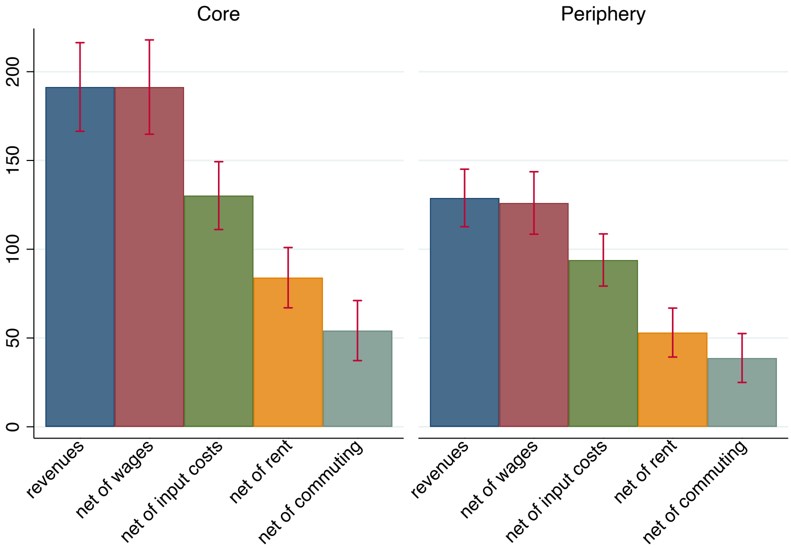
# Correlates of prices

| | (1) | (2) | (3) |
|---|---|---|---|
| | | Unit price | |
| Core | -0.733*** | -0.215 | 0.620** |
| | (0.227) | (0.248) | (0.311) |
| Quality score | 1.032*** | 0.962*** | 0.836*** |
| | (0.195) | (0.191) | (0.183) |
| Number of items | | -0.0361*** | -0.0215*** |
| | | (0.00544) | (0.00674) |
| Business customer | | | -2.255*** |
| | | | (0.419) |
| Product FEs | ✓ | ✓ | ✓ |
| Mean | | 3.805 | |
| Number of Observations | | 2,458 | |

Standard errors in parentheses

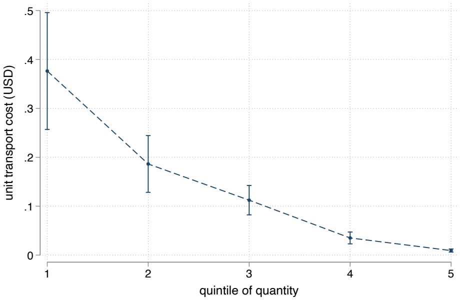
* $p < .10$, ** $p < .05$, *** $p < .01$

# Profits decomposition

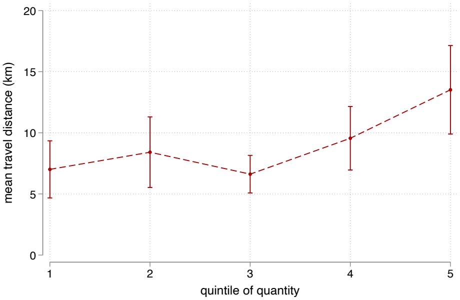


# Large buyers travel further and pay lower unit transport costs

**PANEL A: Unit transport cost**




**PANEL B: Travel distance**




- Unit transport costs decreasing in quantity, despite buyers purchasing larger quantities travelling further
- Suggests transport costs are fixed → *Economies of scale in transport* (Grant and Startz 2022)

Back

# Firms in the Core are more likely to outsource intermediate tasks

| | Core | Periphery | P-value |
|---|---|---|---|
| **PANEL A: Outsourcing** | | | |
| Total number of workers | 2.240 | 1.927 | [0.000] |
| Any external worker | 0.726 | 0.583 | [0.000] |
| Share of external workers | 0.418 | 0.324 | [0.000] |
| **PANEL B: Distance from External Workers** | | | |
| Within 5 minutes walking | 0.954 | 0.557 | [0.000] |
| Between 5 and 15 minutes walking | 0.040 | 0.188 | [0.000] |
| More than 15 minutes walking | 0.005 | 0.257 | [0.000] |

**Note**: Data is from the baseline survey of garment firms. P-values in Panels A and B are from regressions that control for product type Fixed Effects

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# Rent per square-meter


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# Expected Utility from a Location

- Consumers choose **location** to maximize their expected utility:

$$V_{il}^{q} = E_{\varepsilon}\left[\max_{j \in l} u_{ijl}^{q}\right] = q^{\theta}(1-\sigma)\ln\left(\sum_{j=1}^{N_l} \exp\left(\frac{\delta_{jl}^{q}}{1-\sigma}\right)\right) - C_{il} + \gamma$$

where $\delta_{jl} = \beta x_{jl} - \alpha p_{jl} q^{1-\theta} + \xi_j$

- All else equal, expected utility is increasing in $N_l$
  - Observe more $\varepsilon$ draws (more varieties)
  - Higher probability of finding product with desired characteristics

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# High-quality firms are more likely to sort in agglomerated locations

- For illustration, assume there are two types of firms: *low* and *high-quality*
  - Let $N_l^L$ and $N_l^H$ be the number of low and high-quality firms in location $l$
  - Let $s_{iLl}$ and $s_{iHl}$ be the share of type-$i$ customers buying from a low/high quality firm in $l$
- The marginal effects of the entry of a high-quality firm in $l$ on $s_{iLl}$ and $s_{iHl}$ are:

$$\frac{\partial s_{iLl}}{\partial N_l^H} = s_{iLl}\left(s_{H|l}(q^{\theta}(1-\sigma)(1-s_{il})-1) - \frac{\tau_2}{ar_l}(1-s_{il})\right)$$

$$\frac{\partial s_{iHl}}{\partial N_l^H} = s_{iHl}\left(s_{H|l}(q^{\theta}(1-\sigma)(1-s_{il})-1) - \frac{\tau_2}{ar_l}(1-s_{il})\right)$$

- In absolute terms, marginal effect is larger for high-quality firms as $s_{iHl} > s_{iLl}$

$\rightarrow$ **If marginal effect is positive, high-quality firms more likely to sort into large locations**

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# Unconditional shares

- The share of customer $i$ buying products from firm $j$ in location $l$ is:

$$s^q_{ijl}(\mathbf{L},\mathbf{p}) = s^q_{il}(\mathbf{L},\mathbf{p}) \times s^q_{j|l}(\mathbf{p}_l) =$$

$$= \frac{exp(\frac{\delta^q_{jl}}{1-\sigma})\left(\sum_{j'=1}^{N_l} exp(\frac{\delta^q_{j'l}}{1-\sigma})\right)^{q^{\theta}(1-\sigma)-1} exp(-\tau_1 g(||z_i - z_l||) - \tau_2 \frac{N_l}{ar_l})}{exp(u^q_0) + \sum_{k=1}^{N}\left[\left(\sum_{h=1}^{N_h} exp(\frac{\delta^q_{hk}}{1-\sigma})\right)^{q^{\theta}(1-\sigma)} exp(-\tau_1 g(||z_i - z_k||) - \tau_2 \frac{N_l}{ar_l})\right]}$$

Back

# Aggregate demand

- The demand for product $j$ sold in location $l$ is:

$$Q_{jl}(\mathbf{p},\mathbf{J}) = \int q_i s_{ijl}(\mathbf{p},\mathbf{J}) dF(q_i, z_i)$$

where,

- $\mathbf{p}$ and $\mathbf{J}$ are vectors of prices and number of firms across locations
- $dF(\cdot)$ the joint distribution of quantities and distances

Back

# Production function and outsourcing

- Production function: $A_l h^{1-\delta} \ell^{\delta}$
- Firms can employ **internal** or **external** labor (outsourcing)
- Face the following trade-off:
  - Procuring external task requires firms to pay transaction cost $T(N_l)$, $T'(\cdot) < 0$ (Holmes 1995)
  - As firms produce more tasks internally, productivity decreases (Eckel and Neary 2010)
- At optimal outsourcing, cost of labor is $w_l T(N_l)$
- Marginal cost decreasing in $N_l$:

$$c_{jl} = \frac{1}{A_l} \left( \frac{w_l T(N_l)}{\delta} \right)^{\delta} \left( \frac{r_l}{1-\delta} \right)^{1-\delta}$$

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# Production Function

- Firms produce output using labor and land
- Cobb-Douglas CRS production function:

$$f_j(h, \ell) = A_j \ell^{\delta} h^{1-\delta}$$

- Labor is a composite input produced by combining a continuum of perfectly complementary **tasks** $t$:

$$\ell = min\{x(t) | t \in [0, 1]\}$$

# Outsourcing technology

- Tasks can be produced internally or outsourced:
  - **External Technology**: requires $x(t)$ units of labor
  - **Internal Technology**: requires $a(Z)x(t)$ units of labor, with $z$ the share of internally produced tasks
- Firms face the following trade-off:
  - Procuring external task requires firms to pay transport cost $T(N_l)$, $T'(\cdot) < 0$ (Holmes 1995)
  - As firms produce more tasks internally, productivity decreases: $a'(Z) > 0$ (Eckel and Neary 2010)

# Optimal outsourcing

- Assume that cost of internal and external labor ($w$) is the same and constant across locations
- Firms will choose $Z^*$ to equalize the cost of producing tasks internally and externally: $a(Z^*) = T(N_l)$

**Proposition**: As $N_l$ increases $Z^*$ decreases, namely firms outsource a larger share of tasks

Back

# Price choice

- Nash-Bertrand pricing game
- Firms choose price to maximize:

$$\pi_{jl}(\mathbf{p}, \mathbf{L}) = (p_{jl} - c_{jl})Q_{jl}(\mathbf{p}, \mathbf{L})$$

- Net effect of agglomeration on prices is **ambiguous**:
  1. Production externalities reduce marginal costs and hence prices
  2. *Market-share* effect increases competition, lowering prices
  3. *Market-size* effect reduces competition, pushing prices upwards

Back

# Optimal price

- Optimal price is implicitly given by:

$$p_{jl}^{*} = c_{jl} + \frac{(1-\sigma)\int q_i s_{ijl} dF(\cdot)}{\alpha \int q_i s_{ijl}[1 - s_{ij|l}(1 - q_i^{\theta}(1-\sigma)(1-s_{il}))]dF(\cdot)}$$

- Can write the system of best-response equations as (Berry 1994):

$$\mathbf{p} = \mathbf{c} - \Lambda(\mathbf{p})^{-1} Q(\mathbf{p})$$

  where $\Lambda(\mathbf{p})$ is the J $\times$ J matrix of price derivatives

- A **Nash-Bertrand equilibrium** is a vector $\mathbf{p}^*$ that solves this fixed point mapping
- Equilibrium might not be unique

Back

# Equilibrium of location game

- Firms move simultaneously, forming expectations on behavior of other firms
- Firm $j$'s probability of choosing location $l$ is:

$$\Psi_j(l|\mathbf{P}) = \frac{\exp\left( \left(\sum_{\mathbf{l}_{-j}} \left[ \pi_{jl}(l, \mathbf{l}_{-j}) \prod_{h \neq j} P_h(l_h) \right] - \tau_3 g(||z_j - z_l||)\right)/\mu \right)}{1 + \sum_{k=1}^{N} \exp\left( \left( \underbrace{\sum_{\mathbf{k}_{-j}} \left[ \pi_{jk}(k, \mathbf{k}_{-j}) \prod_{h \neq j} P_h(k_h) \right]}_{\text{Expected variable profits in location } k} - \tau_3 g(||z_j - z_k||)\right)/\mu \right)}$$

- **Bayesian Nash Equilibrium** is the fixed point of the system of best response mappings
  - Equilibrium exists, but might not be unique

Back

# Demand Estimation

- Taking firm location and prices as given, maximize log-likelihood function:

$$\ln L(\boldsymbol{\theta_1}|\mathbf{L},\mathbf{p}) = \sum_{i,q,j,l} w_j \times I^q_{ijl} \times \ln s^q_{ijl}(\mathbf{L},\mathbf{p})$$

  - $s^q_{ijl}$: probability that type-$q$ consumer from location $i$ purchases products from firm $j$ in $l$
  - $I^q_{ijl}$: indicator for whether consumer purchases a product from firm $j$ in the data
  - $w_j$: sampling weights
- Assume $\xi_j = 0$, no price endogeneity
  - Use **price from mystery shoppers** exercise: same product, same bargaining
  - Strongly correlated with transaction prices and product quality
  - Uncorrelated with a number of variables that could be related to unobserved quality

Back

# Correlation between transaction and mystery shopper prices

| | (1) | (2) | (3) |
|---|---|---|---|
| | | Transaction price | |
| Mystery shoppers price | 0.925*** | 0.808*** | 1.077*** |
| | (0.122) | (0.100) | (0.065) |
| Quality score | | | 0.461*** |
| | | | (0.111) |
| Product FEs | | ✓ | ✓ |
| Number of Observations | 2,571 | 2,571 | 2,541 |

**Notes**: Robust standard errors in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

# Correlates of Mystery Shoppers prices

| | (1) Price (USD) |
|---|---|
| Quality score (0-100 rating) | 0.241*** |
| | (0.0761) |
| Customer care (0-10 rating) | 0.0533 |
| | (0.0678) |
| Greeted upon entering the firm | -0.249 |
| | (0.460) |
| Given undivided attention | 0.268 |
| | (0.354) |
| Pleasant closing comment | -0.451 |
| | (0.395) |
| Tidiness of premises (0-10 rating) | -0.0475 |
| | (0.0656) |
| Cleanliness of premises (0-10 rating) | 0.164** |
| | (0.0741) |
| Product ready by delivery date | -0.202 |
| | (0.199) |
| Offered something to come back | 0.543 |
| | (0.515) |
| Told to advertise firm | 0.147 |
| | (0.279) |
| Shopper FEs | ✓ |
| Parish FEs | ✓ |
| Number of Obs | 529 |

Standard errors clustered at the parish level in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

# Demand Estimation Robustness

- Given estimates of $\{\sigma, \theta, \tau_1, \tau_2\}$, can solve for $\delta_{jl}^q$ from (Berry 1994):

$$s_{j|l}^q(\mathbf{p}_l) = \frac{\exp(\frac{\delta_{jl}^q}{1-\sigma})}{\sum_{h=1}^{N_l} \exp(\frac{\delta_{hl}^q}{1-\sigma})}$$

- Mean utilities defined as $\delta_{jl}^q = \beta x_j + \alpha p_{jl} q^{1-\theta} + \xi_j$
- Regress estimated $\delta_{jl}^q$ on prices and observable characteristic to obtain $\{\alpha, \beta\}$
- Need IV for prices uncorrelated with unobserved shock $\xi_j$
  - **Cost shifter**: cost of material used in production of typical product
  - **BLP instrument**: share of high-quality firms in same location

Back

# Demand Estimation Robustness

| | (1)<br>Transaction price | (2)<br>Delta |
|---|---|---|
| **Panel A: First Stage** | | |
| Cost of cloth (1 meter) | 0.647*** | |
| | (0.192) | |
| Share high-quality firms | 8.383*** | |
| | (2.450) | |
| | | |
| **Panel B: Second Stage** | | |
| Transaction price | | -0.092** |
| | | (0.038) |
| Product FEs | ✓ | ✓ |
| Number of Observations | 608 | 608 |

**Notes**: Robust standard errors in parentheses. * $p < .10$, ** $p < .05$, *** $p < .01$

Back

# Customers' origin

- Missing consumer origin for 34% of transactions
- Uncorrelated with transaction and firm characteristics
- Imputed from origin of consumers of the same type, shopping in the same location via proportional random assignment

| | (1) Missing Origin |
|---|---|
| Transaction value | 0.000 |
| | (0.000) |
| Number of daily customers | -0.040 |
| | (0.039) |
| Daily revenues | -0.001 |
| | (0.001) |
| Retail customer | -0.075* |
| | (0.037) |
| Parish FEs | yes |
| Number of Observations | 2589 |

Standard errors in parentheses

* $p < .10$, ** $p < .05$, *** $p < .01$

Back

# Supply Estimation

- Use optimal choice of labor ($\ell^*$) and land ($h^*$)
- Take input costs from data:
  - Wages assumed to be constant in periphery, but allowed to be different in Core
  - Rent exogenously varies across location, but not explicitly modelled
- Parametrization: $T(N_l) = 1 + N_l^T$ (iceberg transport cost)
- Estimate using Simulated Method of Moments
  - **Parameters** to be estimated: $\{\delta, T(N_l), A_l\}$
  - **Targeted moments**: average ratio of land/labor, and variance of labor and land in each parish

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# Identification of Supply Parameters

$$h^*_{jl} = \frac{Q_{jl}}{A_l}\left(\frac{(1-\delta)wT(N_l)\epsilon_j}{\delta r_l}\right)^{\delta} \qquad \ell^*_{jl} = \frac{Q_{jl}}{A_l}\left(\frac{\delta r_l}{(1-\delta)wT(N_l)\epsilon_j}\right)^{1-\delta}$$

- Ratio across locations $l, h$: $\frac{\ell^*_{jl}/h^*_{jl}}{\ell^*_{hk}/h^*_{hk}} = \frac{r_l w_k T(N_k)}{r_k w_l T(N_l)}$
- Expected within location $l$: $\frac{h^*_{jl}}{\ell^*_{jl}} = \frac{(1-\delta)wT_1(J_l)}{\delta r_l}$

  $\rightarrow$ **Ratios** identify $T_1(J_l)$ and $\delta$
- Given $Q_{jl}$, recover location productivity $A_l$ from **levels** $h^*_{jl}$ and $\ell^*_{jl}$

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# Location Estimation

- A fixed point of Rust's NFXP algorithm is a pair $\{\tau_3^*, \mathbf{P}^*\}$ that satisfies:
  (i) $\tau_3^* = \arg\max_{\tau_3} \sum_j \sum_l \ln \Psi_j(l|\mathbf{P}^*, \tau_3) I_{lj}$
  (ii) $\mathbf{P}^* = \Psi(\mathbf{P}^*, \tau_3^*)$
- Where the best response mapping is:

$$\Psi_j(l|\mathbf{P}) = \frac{\exp\left(\left(\sum_{\mathbf{l}_{-j}} \left[\pi_{jl}(l, \mathbf{l}_{-j}) \prod_{h \neq j} P_h(l_h)\right] - \tau_3 g(||z_j - z_l||)\right)/\mu\right)}{1 + \sum_{k=1}^{N} \exp\left(\left(\sum_{\mathbf{k}_{-j}} \left[\pi_{jk}(k, \mathbf{k}_{-j}) \prod_{h \neq j} P_h(k_h)\right] - \tau_3 g(||z_j - z_k||)\right)/\mu\right)}$$

- Must compute Nash-Bertrand equilibrium and variable profits $\pi_{jl}$ for all possible configuration of firms in space $\mathbf{l}_{-j}$
- $\mu$ not separately identified: calibrated to 0.75 of a standard deviation of profits

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# Location Estimation: Reducing the state space

1. **Choice set**: stay in parish where the owner resides or move to Core
2. **Firm heterogeneity**: high or low-quality
   - But type also a function of owner's parish: order of magnitude of state space is $10^{243}$
3. **Information**: know number of firms of each type $\{N_{low}, N_{high}\}$, but not parish of origin
   - Assume owners are uniformly distributed among periphery parishes
   - Limited knowledge: *representative parish* in the periphery

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# Location Estimation: Simplified best response mapping

- Let $n_{low}$ and $n_{high}$ be the number of low and high-quality firms (other than $j$) in the core
- Let $\mathbf{P} = \{P_{low}, P_{high}\}$ be the vector of CCPs of any low and high-quality firm entering the core

$$\Psi_j(l|\mathbf{P}) = \frac{\exp\left( (\sum_{n_{low},n_{high}} \left[ \pi_{jl}(l, n_{low}, n_{high}) Pr(n_{low}, n_{high}) \right] - \tau_3 g(||z_j - z_l||))/\mu \right)}{1 + \sum_{k=1}^{N} \exp\left( (\sum_{\mathbf{k}_{-j}} \left[ \pi_{jk}(k, n_{low}, n_{high}) Pr(n_{low}, n_{high}) \right] - \tau_3 g(||z_j - z_k||))/\mu \right)}$$

- The probability that $n_{low}$ and $n_{high}$ low and high-quality firms enter the core is:

$$Pr(n_{low}, n_{high}) = \binom{N_{low}}{n_{low}} (P_{low})^{n_{low}} (1 - P_{low})^{N_{low} - n_{low}} \times \binom{N_{high}}{n_{high}} (P_{high})^{n_{high}} (1 - P_{high})^{N_{high} - n_{high}}$$

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# Estimated Parameters

| | Parameter | Estimate | Std Error |
|---|---|---|---|
| **PANEL A: Demand** | | | |
| Price (USD) | $\alpha$ | -0.064 | (0.016) |
| Quality final customers | $\beta_f$ | 0.205 | (0.083) |
| Quality retail customers | $\beta_r$ | 0.724 | (0.377) |
| Taste shocks correlation | $\sigma$ | 0.329 | (0.210) |
| Quantity multiplier | $\theta$ | 0.316 | (0.083) |
| Travel cost | $\tau_1$ | -0.139 | (0.016) |
| Within location search cost | $\tau_2$ | -0.0004 | (0.0004) |
| **PANEL B: Supply** | | | |
| Labor share | $\delta$ | 0.651 | (0.030) |
| Outsourcing cost | T | -0.521 | (2.170) |
| Productivity Core | $A_{core}$ | 17.950 | (3.035) |
| Productivity Periphery (mean) | $A_{per}$ | 10.886 | (2.647) |
| **PANEL C: Location** | | | |
| Commuting cost | $\tau_3$ | -5.739 | |

**Note**: Standard errors bootstrapped using 100 bootstrapped samples.

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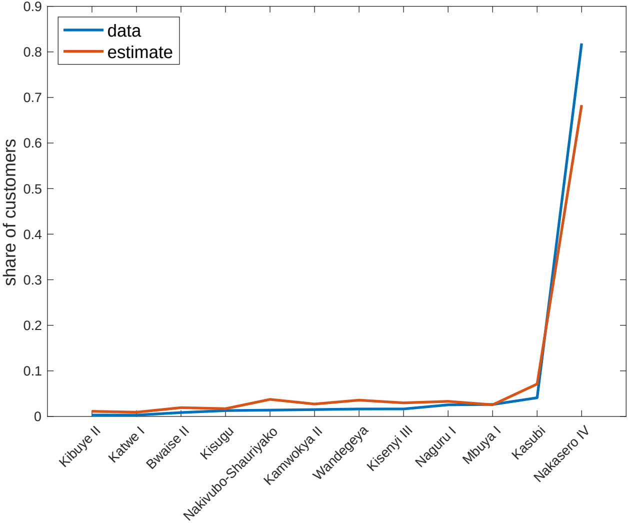
# Model Fit: Parish Demand Shares

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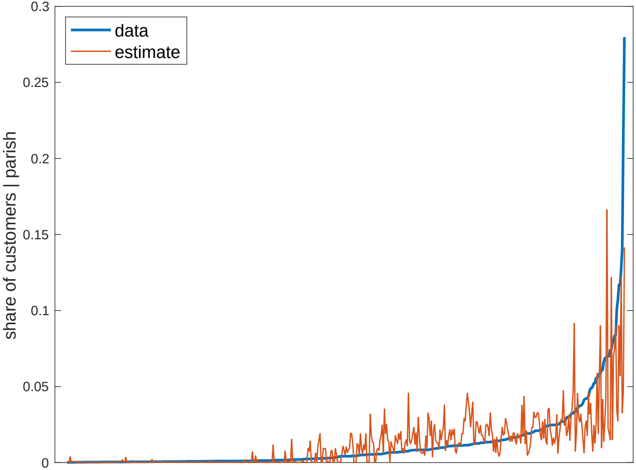
# Model Fit: Within Location Firm Shares

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# Model Fit: Choice of Land and Labor

| **Parish** | | Land ($h$) | Labor ($\ell$) |
|---|---|---|---|
| Bwaise II | *Data* | *6.050* | *1.931* |
| | Sim | 5.890 | 2.333 |
| Kamwokya II | *Data* | *5.450* | *1.650* |
| | Sim | 5.466 | 1.594 |
| Kasubi | *Data* | *5.003* | *2.246* |
| | Sim | 4.736 | 2.711 |
| Katwe I | *Data* | *1.750* | *1.500* |
| | Sim | 1.989 | 1.045 |
| Kibuye II | *Data* | *2.857* | *2.429* |
| | Sim | 2.671 | 2.619 |
| Kisenyi III | *Data* | *3.450* | *2.450* |
| | Sim | 3.823 | 0.948 |
| Kisugu | *Data* | *7.750* | *1.938* |
| | Sim | 7.347 | 2.943 |
| Mbuya I | *Data* | *9.394* | *2.314* |
| | Sim | 9.194 | 2.941 |
| Naguru I | *Data* | *3.862* | *2.353* |
| | Sim | 4.192 | 1.224 |
| Core | *Data* | *2.671* | *2.321* |
| | Sim | 2.808 | 2.167 |
| Nakivubo-Shauriyako | *Data* | *4.533* | *2.467* |
| | Sim | 3.282 | 3.606 |
| Wandegeya | *Data* | *2.478* | *2.696* |
| | Sim | 2.217 | 2.896 |

**Notes**: Robust standard errors in parentheses. $^{*}$ $p < .10$, $^{**}$ $p < .05$, $^{***}$ $p < .01$

# Counterfactual 2: E-commerce platform

| | **Baseline** | **E-Commerce** |
|---|---|---|
| Share of firms in core | 0.365 | 0.222<br>**-39%** |
| Share of sales in core | 0.382 | 0.065<br>**-83%** |
| Average price | 20.44 | 17.38<br>**-15%** |
| Average profits | 476.0 | 411.3<br>**-14%** |
| Average consumer welfare | 19.22 | 31.80<br>**+71%** |

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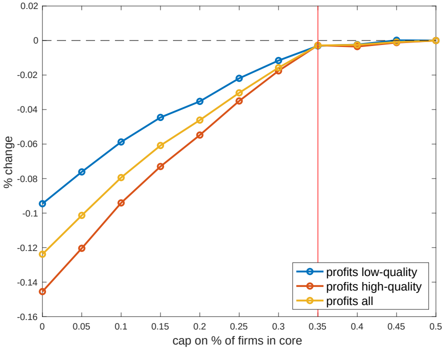
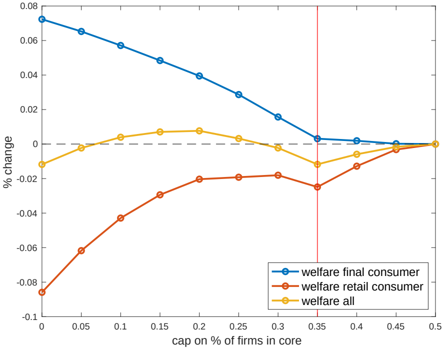
# Counterfactual 3: Capping the number of firms in the core

Panel A: Firm Profits




Panel B: Consumer Welfare

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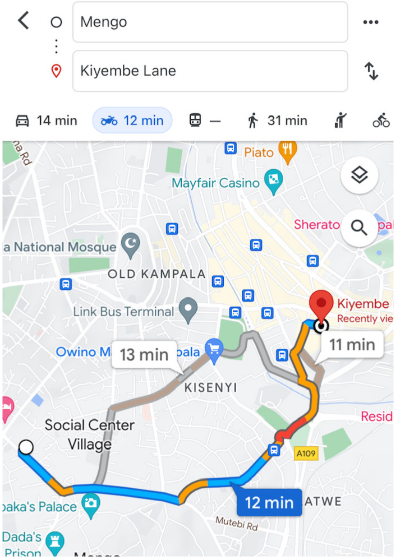
# Banning boda-bodas from the core




- Travel time separately for cars and motorcycles
  - No ban: min$\{car, motorcycle\}$; Ban: car
  - Applies to part of the journey within central district
- Increase in travel for customers (5.2%) and firm owners (6.8%)
- 9.8% of firms relocate in the periphery
- Small increase in average profits, but:
  - $-3.6\%$ in core, $+3.3\%$ in periphery

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