Slack and Economic Development

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Motivation

- old hypothesis of capacity under-utilization in poor economies (Lewis, 1954)
  - confirmed in contemporary cross-country data
- potentially important implications for macroeconomic dynamics
  - slack is a direct cause of low productivity
  - slack implies highly elastic aggregate supply curves (Michaillat and Saez, 2015)
  - rationalizes large empirical multipliers in developing economies (Gerard et al., 2021; Egger et al., 2022; Galego Mendes et al., 2023)
- yet, despite cross-country empirical patterns and theoretical hypotheses:
  1. little empirical evidence at the micro-level
  2. no coherent theoretical micro-foundation

An underappreciated ’stylized fact’ in development

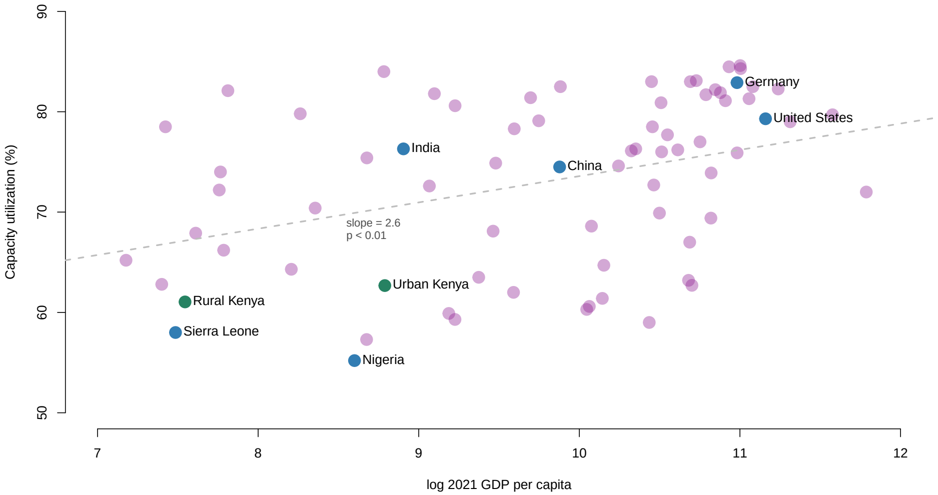

Figure 1: Capacity utilization across the world

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This paper

Micro causes and macro implications of capacity under-utilization in small firms

- document substantial under-utilization using novel data from rural and urban Kenya
  - detailed measures of overall, labor, and capital utilization, and shopping patterns
  - more slack in small firms and in 'thin' markets
- develop a structural spatial model of capacity utilization in general equilibrium
  - key friction: integer constraints or indivisibilities of input factors in small firms
  - estimate using rich RCT micro data from rural Kenya (Egger et al., 2022)
- insights for macroeconomic dynamics in development:
  - consistent with large real demand multipliers in response to fiscal policy
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Outline

1. Descriptive statistics on under-utilization in Kenya
2. A structural model of general equilibrium slack due to integer constraints
3. Model estimation and validation
4. Validation using a large scale RCT

Descriptive statistics on under-utilization in Kenya

Measuring slack

Novel measures of capacity utilization for a representative 5,000 (non-agricultural) enterprises in rural Kenya and the capital Nairobi (correlation table):

- Overall capacity utilisation:
  - Direct survey question (analogous to US census of manufacturing): 61% (U.S. $\approx$ 80%)
- Labor: public observation reveals only 50% of time spent on productive activities in rural markets, 83% in Nairobi
- Capital: machines only operate 72% of the time (e.g. grain mills), both in rural markets and Nairobi
- Marginal costs: 30% of rural firms say it would cost them nothing to expand production by 10%, only 17% in Nairobi markets

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Three stylized facts

1. more slack in poor economies
2. small firms have more slack
3. remote markets have more slack

2. Small firms have more slack

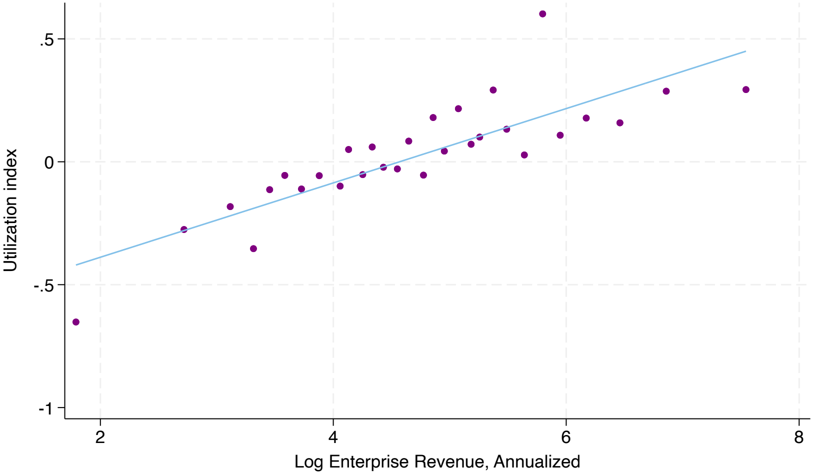

Figure 2: Utilization index by firm revenue (residualised by sector and firm location)

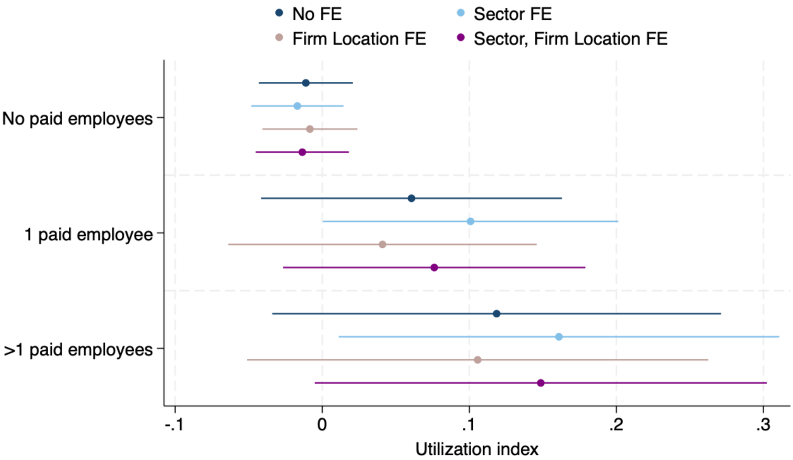

Figure 3: Utilization index by firm size

3. Remote and rural markets have more slack (seasonality)

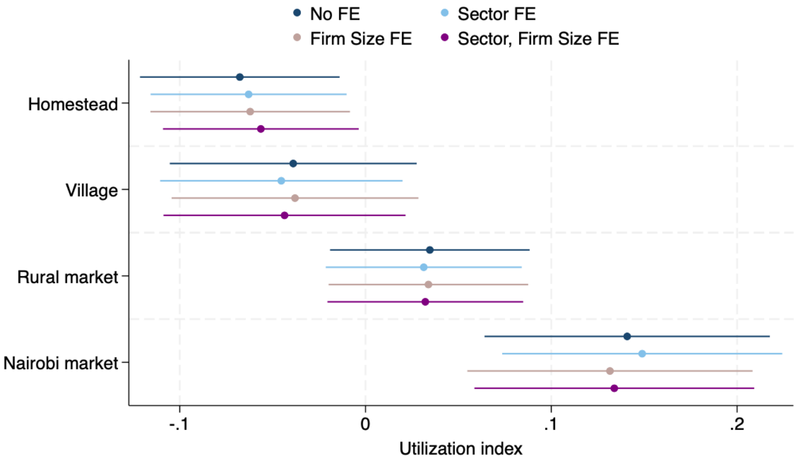

Figure 4: Utilization index by firm location

A model of slack in general equilibrium

Demand

Two sectors, tradeable agriculture X and non-tradeable services Y:

$$U = Y^{\alpha} X^{1-\alpha}$$

Y itself normalized CES composite of different service varieties:

$$Y = M^{\frac{1}{1-\theta}} \left(\int_{\Omega} y(\omega)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}}$$

Spatial:

- consumers live in villages $v \in V$
- shop bundle at markets $m \in M$ based on on idiosyncratic taste and transport cost

→ Map of Shopping Flows → Shopping Flows Algebra

Supply

1. Agriculture
   - produced with labor N_X: $X = AN_X^{1-\beta}$
   - N_X being paid market wage w_X, freely traded at world price $p_X = 1$
2. (retail) Services
   - continuum of monopolistically competitive firms, producing retail varieties
   - every variety i produced with labor n and effort e

$$y_i = \varphi_i \min\{e, n\}, \quad n \in \mathbb{N}$$

     n is paid w_y, effort e is paid a constant piece-rate ν, productivity $\varphi \sim \text{Pareto}(\varphi_0, \eta)$
   - n is integer constrained, i.e. only available in indivisible units $1.0, 2.0, 3.0, \cdots$

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Profit maximisation in the service sector

- Monopolistic firm faces CES demand $D(p) = \zeta p^{-\theta}$ and solves

$$\max_{p,n\in\mathbb{N}} D(p)\left(p - \frac{\nu}{\varphi}\right) - w_y(n-1) \ \text{ s.t } \ D(p) \leq \varphi n$$

  with ν marginal cost of effort, w_y the wage
- if the firm is unconstrained, $e < n$, acts as CES monopolist: $p^u = \frac{\theta}{\theta-1}\frac{\nu}{\varphi}$
- if the firm is constrained, $e = n$, raises price to meet demand: $p^c = \left(\frac{\varphi n}{\zeta}\right)^{-1/\theta}$
- cutoff rules:
  - $\varphi^f(n)$: point where firm with n employees is fully constrained
  - $\varphi^+(n+1)$: point where firm optimally hires the $(n+1)$th employee

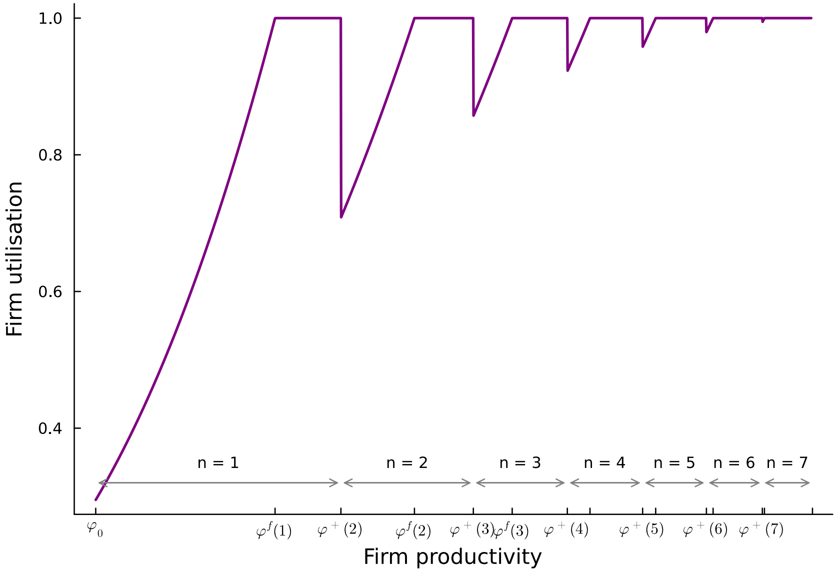

Figure 5: Optimal utilisation across productivity distribution

Equilibrium

Entry. Potential entrants decide between wage work and Y-sector entrepreneurship. Mass of entrants M equalises wage and expected profit:

$$\int \Pi^{Y}(\varphi)dG(\varphi) = w$$

Equilibrium.

1. Sectoral mobility: $w_x = w_y$
2. Profit maximization in both sectors
3. Free entry
4. Labor markets and goods market clear

→ Eqm. conditions

Household income.

$$I = \underbrace{w_y N_Y}_{\text{wage payments}} + \underbrace{\nu \int_{\omega} e_{\omega} d\omega}_{\text{effort payments}} + \underbrace{\int_{\omega} \Pi^{Y}_{\omega} d\omega}_{\text{retail profits}} + \underbrace{AN_X^{1-\beta}}_{\text{ag. VA}} + \underbrace{\Delta}_{\text{cash transfer}}$$

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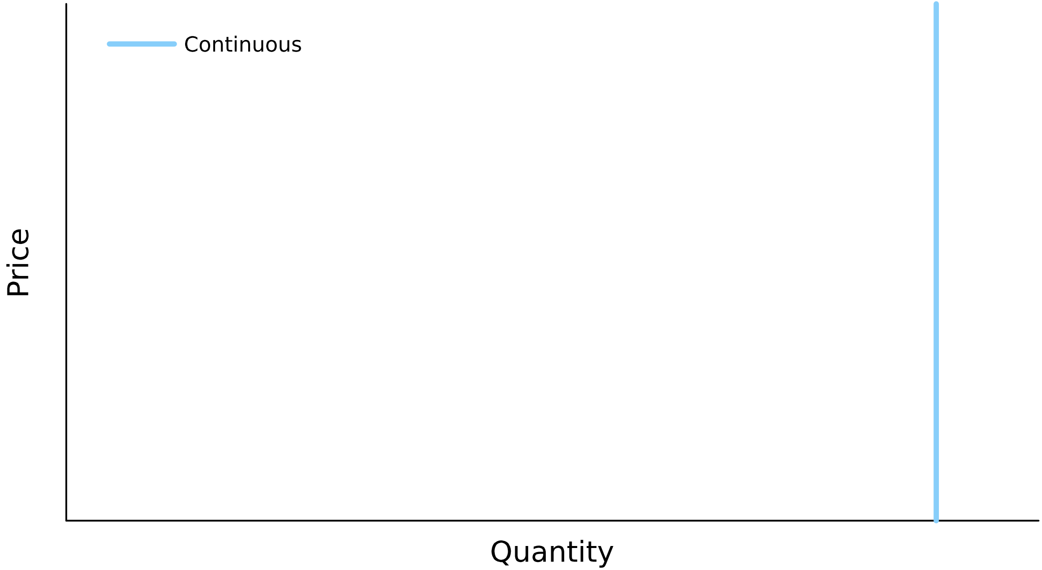
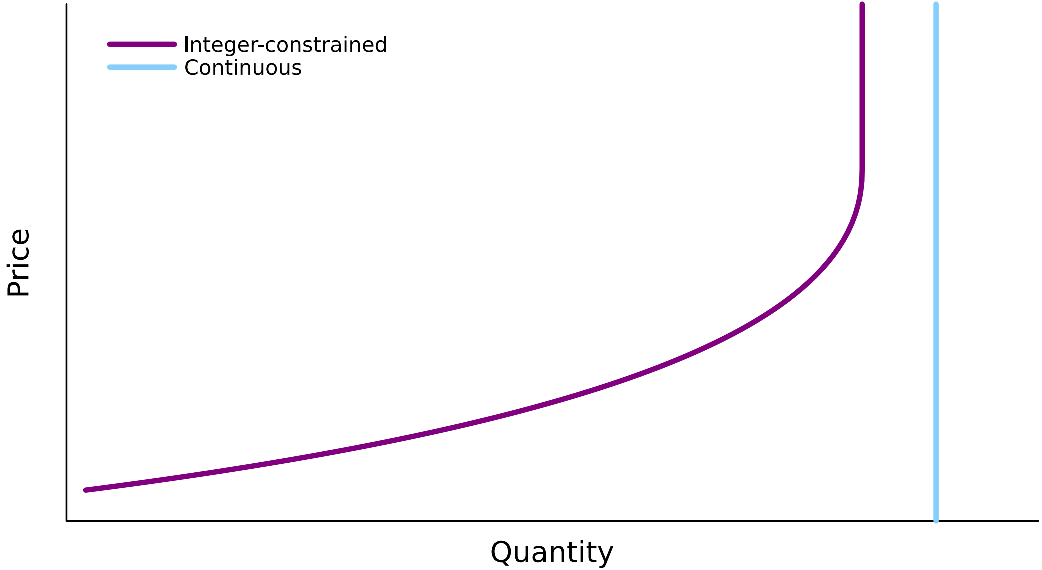


Figure 6: Integer constrained supply curves (misallocation maths)



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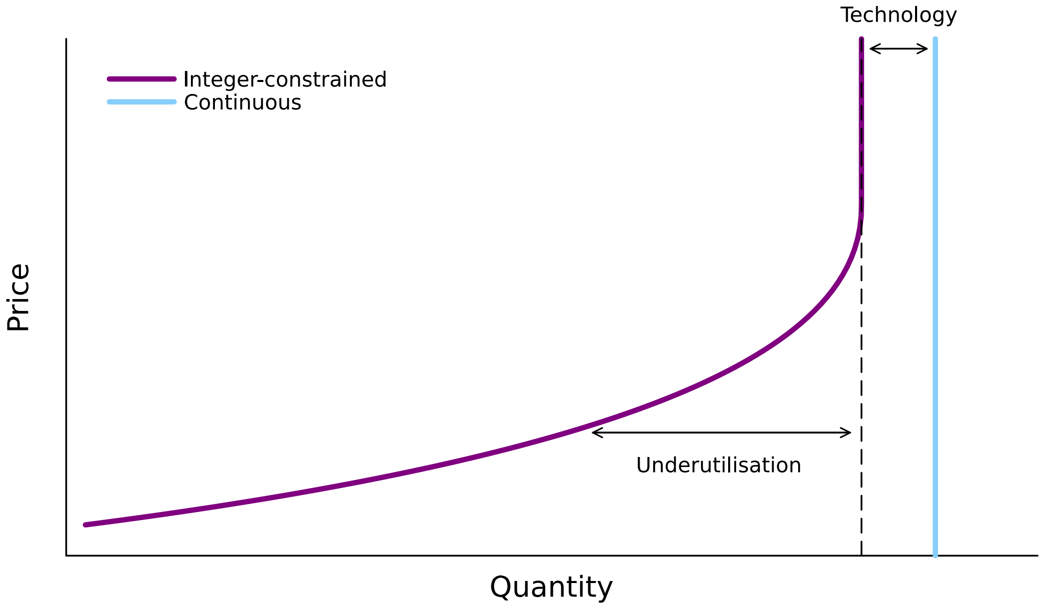

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Model validation with cash transfer RCT

We proceed in two parts:

1. estimate / calibrate structural parameters using baseline data

$$\begin{bmatrix} \eta \\ \nu \\ \theta \end{bmatrix} \rightarrow \begin{bmatrix} \text{Share of revenue accounted by top 20\% of firms} \\ \text{Share of firms below full capacity} \\ \text{Variable profit-share (Rev - var. Costs)/Rev} \end{bmatrix}$$

   Remaining parameters standard values from literature / read off data
   $\rightarrow$ Calibration details. $\rightarrow$ Baseline Fit.

2. detailed validation exercise against results from cash transfer experiment in Egger et al. (2022)

We proceed in two parts:

1. estimate / calibrate structural parameters using baseline data
2. use cash transfer experiment from Egger et al. (2022) to
    - map the model to the RCT geography
    - replicate the RCT exacly within the model
    - validate model predictions against out-of-sample reduced-form evidence

$\rightarrow$ Experiment details

Methodological innovation: pre-specify parts of the structural estimation routine and untargeted validation moments in pre-analysis plan (AEA Trial Registry #13210)

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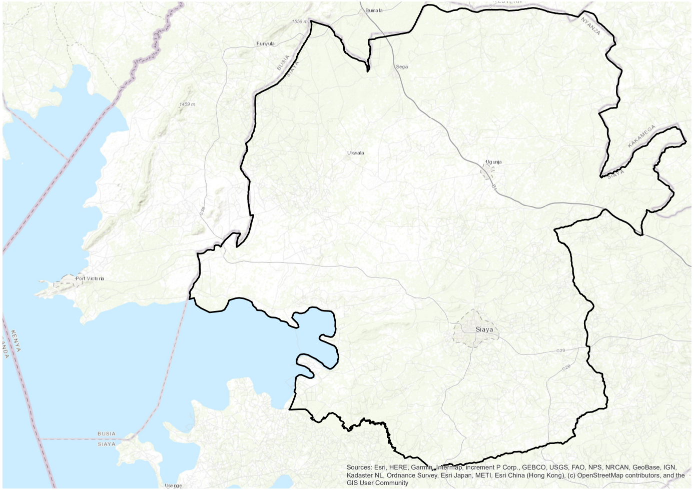
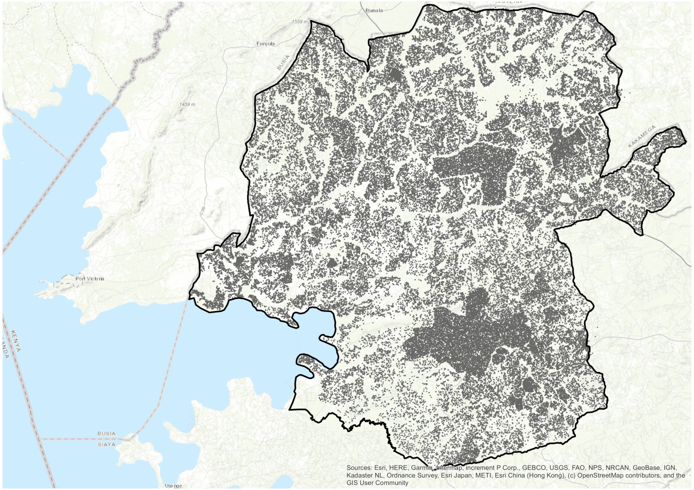

Bumala
Funyula
BUSIA
SIAYA
Sega
Ukwala
Ugunja
NYANZA
KAKAMEGA
Port Victoria
Siaya
KENYA
BUSIA
SIAYA
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Mapping the model to the Egger et al. (2022) geography

population ≈ 400k



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- 5 towns (19%)
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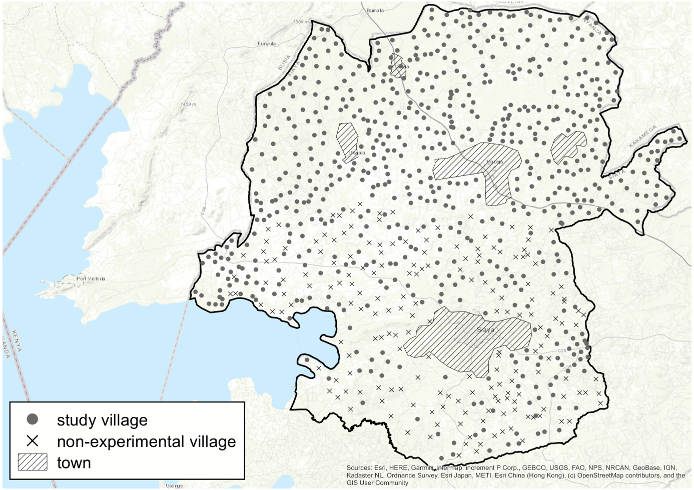

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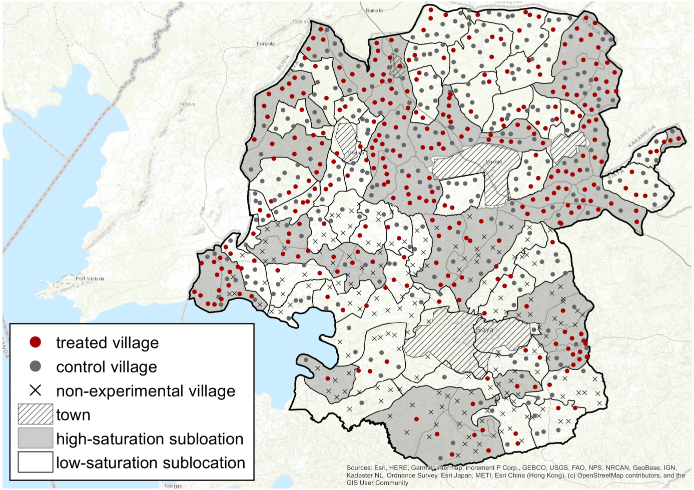

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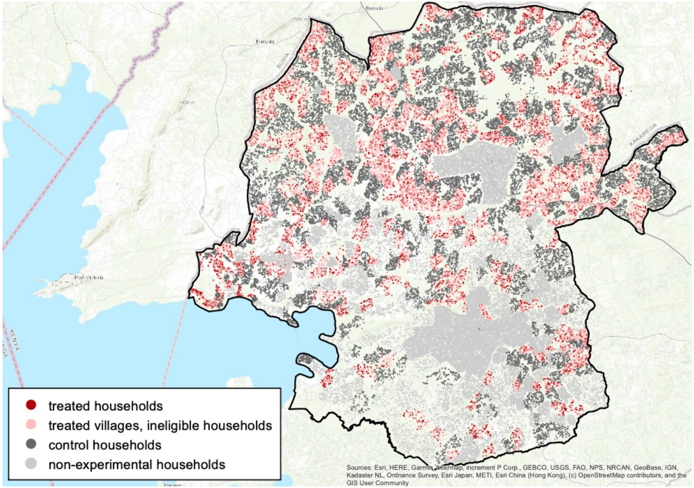

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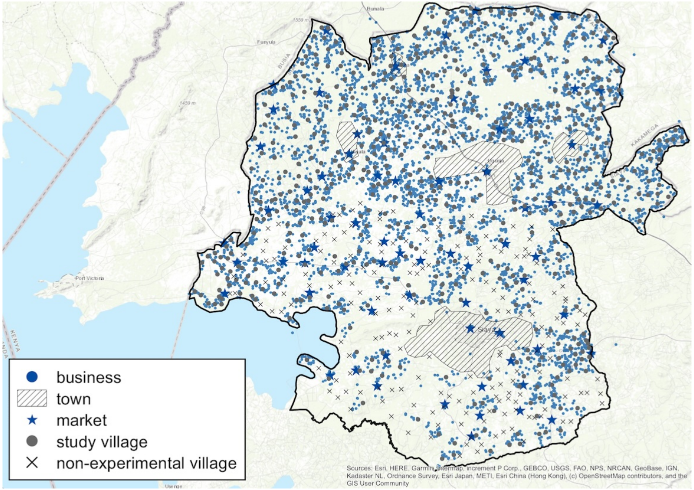
consumption

- 71 markets
- rich data on shopping to estimate gravity (details)

production

- 20k enterprises (8k in markets)



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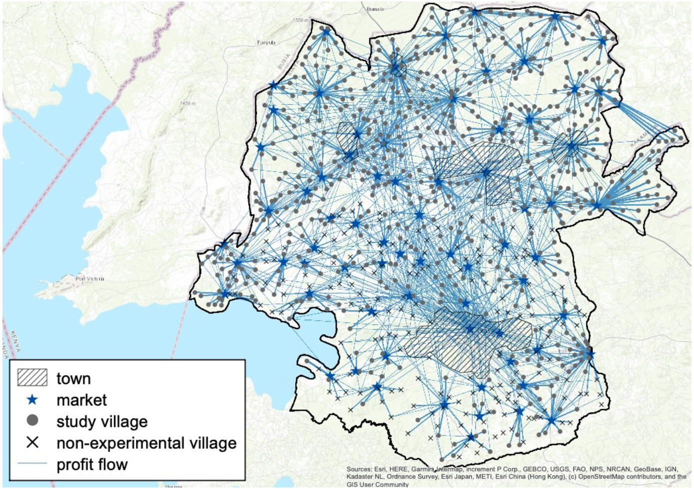
production

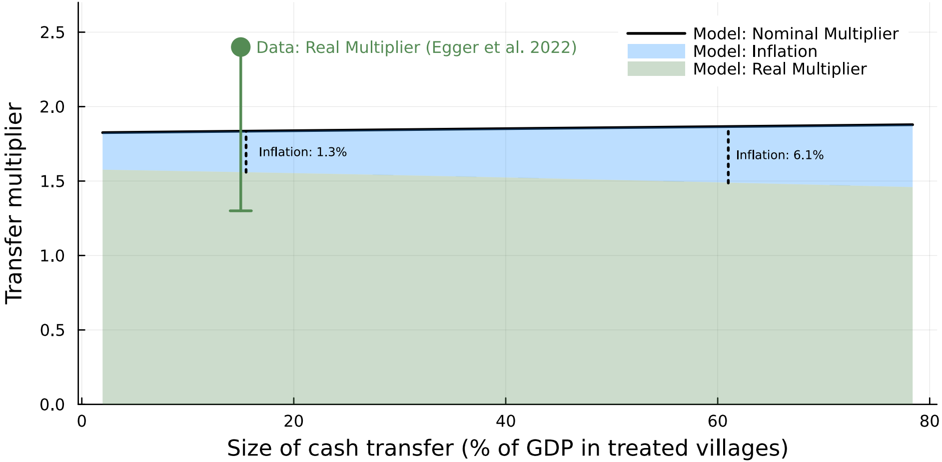
- 20k enterprises (8k in markets)
- ownership matrix assigns profits
- land/labor supply at closest market



Quantitative results

1. replicate the experiment within the calibrated model geography
    - compare overall cash multiplier (real and nominal)
2. Model validation against experimental data
3. applications

The transfer multiplier (multiplier arithmetic)



Quantitative results

1. replicate the experiment within the calibrated model geography
2. not today: prespecified model validation against experimental data
    - output increase/inflation response by baseline slack and market access
    - by firm size
    - reallocation from agriculture to service sector
    - gains in control villages/'missing intercept' problem
      → income → inflation
3. applications

Comparative Statics

	M_{nominal}	M_{real}	Inflation
Headline specification	1.834	1.560	1.28%
10× outside demand	2.235	1.098	5.04%
Low transport cost to urban markets	2.085	1.352	2.45%
No Sectoral Mobility	2.538	1.631	4.00%
Continuous benchmark	1.820	1.135	3.21%

→ Multiplier Maths

Conclusion

- substantial slack among small firms consistent with integer constraints
  - document empirically
  - quantify contribution to elastic supply curves in poor economies
- aggregate implications for development policy
  - lack of demand a first order constraint on productivity of rural enterprises
  - large macro returns to relaxing these constraints with demand side policies
  - for high slack microenterprises, supply side constraints arguably less important

Thank you!!

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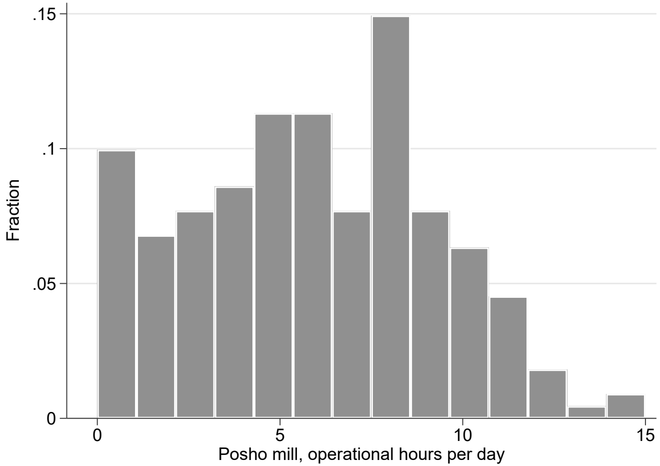
Utilisation of posho mills



→ back

Correlation between slack measures

	Overall capacity util	Labor util	Capital util	Cust per hr	Zero MC	Util index
Overall capacity util	1					
Labor util	-0.0409	1				
Capital util	-0.0296	-0.0987	1			
Cust per hr	0.1378*	-0.0495	0.1355*	1		
Zero MC	0.0122	0.0027	-0.0752*	-0.0391	1	
Util index	0.4963*	-0.04	0.9698*	0.1589*	-0.3820*	1

(back)

Equilibrium Conditions

1. sectoral mobility: $w_X = w_Y = w$

2a price-taking in X sector: $N_X = \left(\frac{\beta A}{w}\right)^{\frac{1}{1-\beta}}$

2b profit maximisation in Y sector: behavior according to $\varphi^f(n), \varphi^+(n) \quad \forall n$

3 Free entry: $\int \Pi^Y(\varphi) dG(\varphi) = w$

4a Labor market clears: $N_X + N_Y = M$

4b Goods market clears: $\int_\omega \zeta p(\omega)^{1-\theta} d\omega = I$

→ Back

Demand multiplier

The local economy is closed + Cobb-Douglas demand for $X \implies I = \frac{AN_x^{1-\beta}+\Delta}{1-\alpha}$

Effect of a transfer is

$$\frac{dI}{d\Delta} = \frac{1}{1-\alpha} + \frac{1-\beta}{1-\alpha} AN_x^{-\beta} \frac{dN_x}{d\Delta}$$

Without sectoral mobility $\frac{dN_x}{d\Delta} = 0 \implies \frac{dI}{d\Delta} = \frac{1}{1-\alpha}$

Real multiplier

- Real response

$$M^{Real} = \frac{dX}{d\Delta} + Pd\frac{dY}{d\Delta}$$

- Without Reallocation and No Integer Constraint $dY = 0, dX = 1 \implies M^{Real} = 1$
- With Reallocation/Integer Constraint

$$\frac{dPY}{d\Delta} = \frac{\alpha}{1-\alpha} = P\frac{dY}{d\Delta} + Y\frac{dP}{d\Delta}$$

(back)

Integer Constraints and Aggregate Productivity

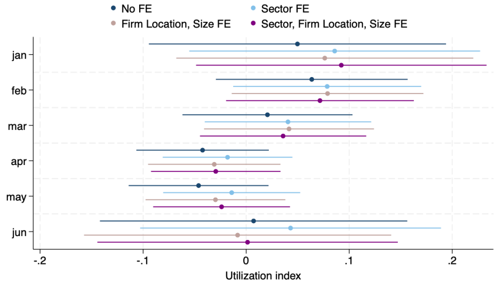
- Aggregate non-tradable output

$$Y = \left(M^e \sum_{n \in \mathbb{N}} A(n) n^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}$$

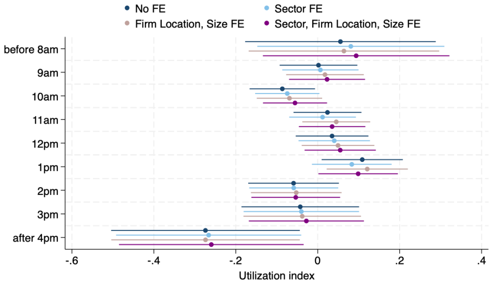
  where $A(n)$ is endogenous productivity of firms with employment n
- Integer constraints affect $A(n)$ in two ways:
  - **Unconstrained** firms with n: Desired input level lower than $n \implies A(n) \downarrow$
  - **Constrained** firms with n: Heterogeneous producers with same input $\implies$ A(n) $\downarrow$
- Implications for aggregate productivity:
  - Productivity of **unconstrained** firms is **demand-driven**
  - Firm size not aligned with productivity - **misallocation**

(back)

Figure 7: Capacity utilisation across demand cycles



(a) Utilisation by time of year



(b) Utilisation by time of day

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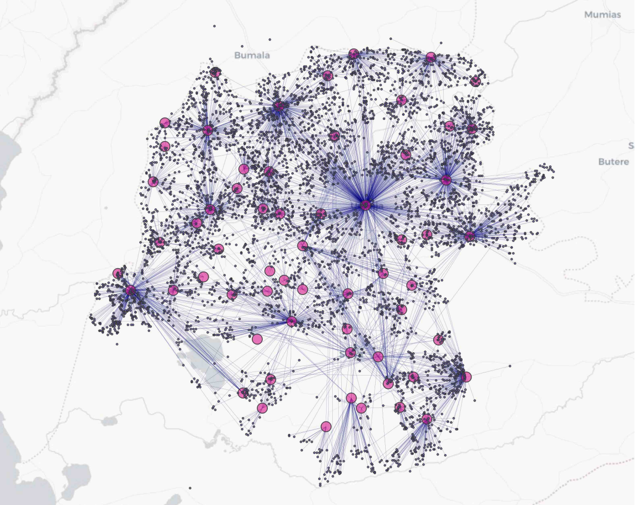
Spatial Extension

- Consumers live in villages $v \in V$
- Firms produce in markets $m \in M$
- Shopping based on prices P_m and trade cost τ_{vm}
- Price elasticity σ based on idiosyncratic taste



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Spatial extension.

1. villages $v \in V$, each home to N_v consumers, markets $m \in M$ in spatial competition
2. consumer c observes prices at each market m and decides where to shop for Y

$$u_{cvm} = \frac{I_v}{P_m} \frac{z_{cvm}}{D_{vm}}, \quad z_{cvm} \sim \text{Frechet}(\sigma)$$

   with $D_{vm} = \exp(\kappa \tau_{vm} - \gamma_m)$, where τ_{vm} is distance (Ahlfeldt et al., 2015) and γ_m is a demand shifter. Yields shopping probabilities:

$$\pi_{vm} = \frac{(P_m D_{vm})^{-\sigma}}{\sum_{m'} (P_{m'} D_{vm'})^{-\sigma}}$$

   → Demand shifters and market size
3. spatial equilibrium: previous eqm. 1-5. in all locations, plus above probabilities.

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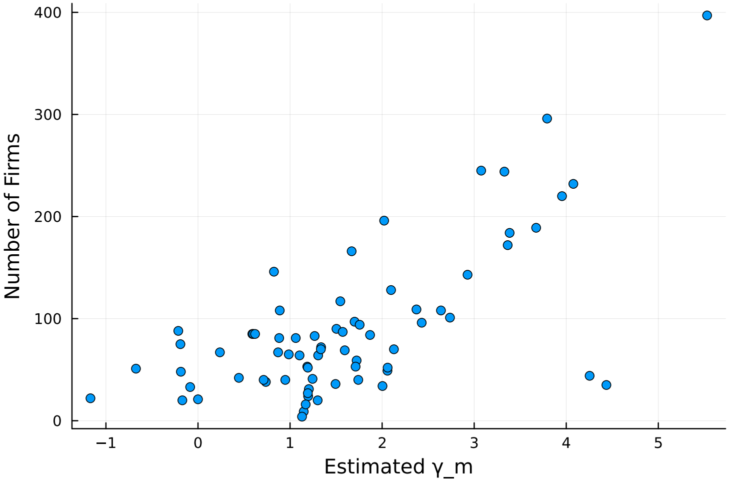
Estimated demand shifter versus market size



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The Egger et al. (2022) experiment

We validate the model in the context of the economy-wide effects of a large-scale unconditional cash transfer in Western Kenya

- Well-identified RCT evidence on the GE impacts of a large demand shock
  - 300,000 people across 653 villages
  - two-stage clustered randomisation creates spatial variation in demand shock (map)
  - cash injection equivalent to 16% of local GDP
- Key findings:
  - large consumption response of households: marginal propensity to spend of 0.9
  - large increase in local production, with little movement in factor input quantities or prices
  - limited price inflation (<1%)
  - real transfer multiplier of 2.4

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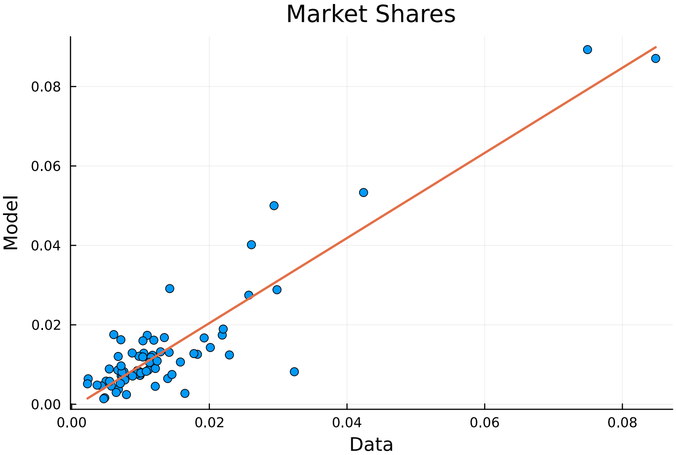
Calibration and estimation strategy for single-location economy. → back

Parameter	Source	Value
Cobb Douglas share of non-ag, non-tradeable α	read from consumption data	0.606
DRS parameter for ag production β	Adamopoulos and Restuccia (2020)	0.49
Scale of productivity Pareto q	normalise	1.0
Total land in the economy Λ	normalise	1.0
Total population N	normalise	1.0
Agricultural technology A	match agricultural production	122.33
Value of baseline remittances Δ_0	read from income data	28
Shape of productivity Pareto η	estimate via SMM (revenue share of top quintile)	2.682
Marginal cost of effort ν	estimate via SMM (share of firms below full capacity)	111.76
CES elasticity within locations θ	estimate via SMM (variable profit share)	3.435
Spatial gravity parameter σ	Standard value	4.00
Sensitivity of transport cost to distance κ	estimate directly via gravity	0.22
Demand shifter γ_m	estimate directly via gravity	-

Baseline fit of the model

Model fits well to baseline

- **market sizes**
- shopping patterns / gravity
- firm size distribution



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Baseline fit of the model

Model fits well to baseline

- market sizes
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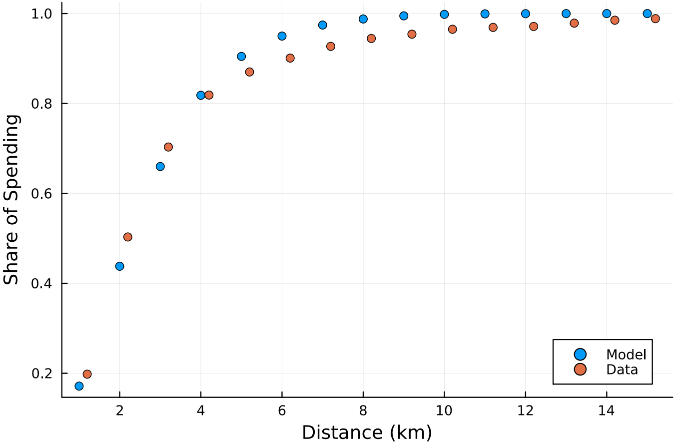


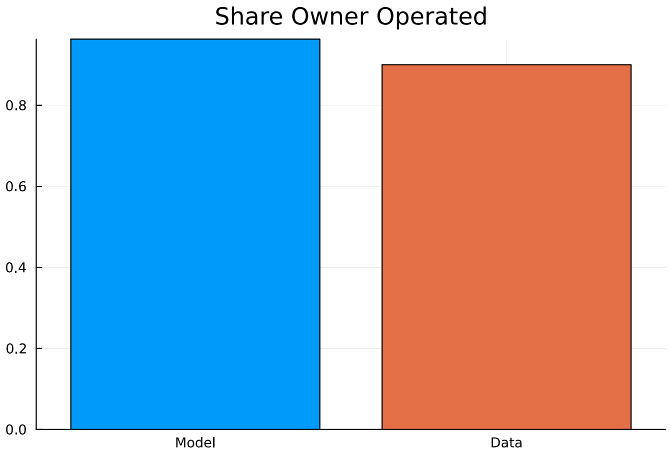
→ Gravity by Sector

→ back

Baseline fit of the model

Model fits well to baseline

- market sizes
- shopping patterns / gravity
- **firm size distribution**



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Multiplier arithmetic (back)

Estimates from Egger et al. (2022)

Real multiplier	2.44
Inflation	0.4%

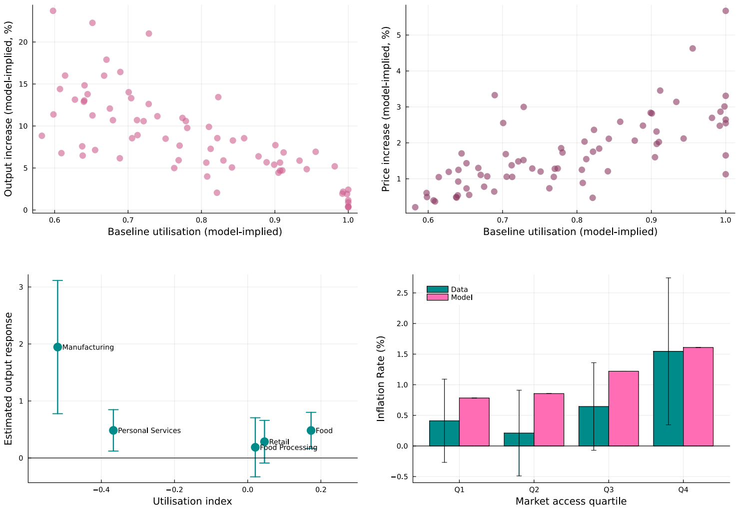
In the model

Nominal multiplier	1.83
Inflation	1.2%
Real multiplier	1.56

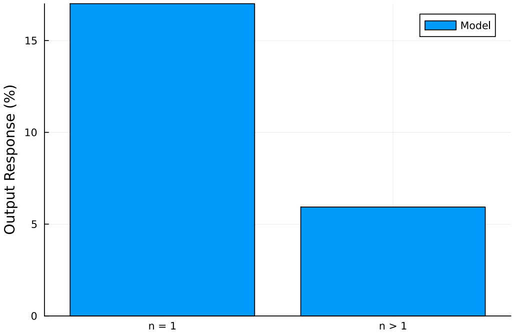
5% (transfers in % of GDP)	*	1.83 (nominal multiplier)	=	9.2% (nominal GDP increase)

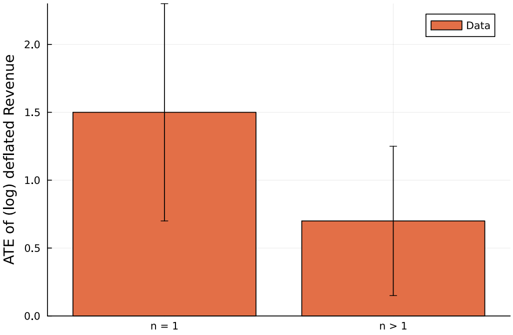
-1.2% (inflation)	=	8% (real GDP increase)	/	5% (transfers in % of GDP)	=	1.6 (real multiplier)

Role of utilisation and market access → Back



Mechanism: output response by firm size





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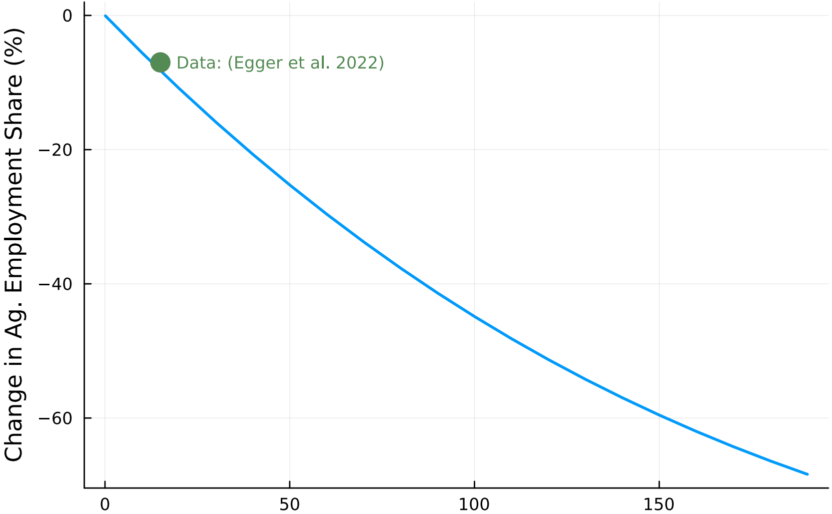
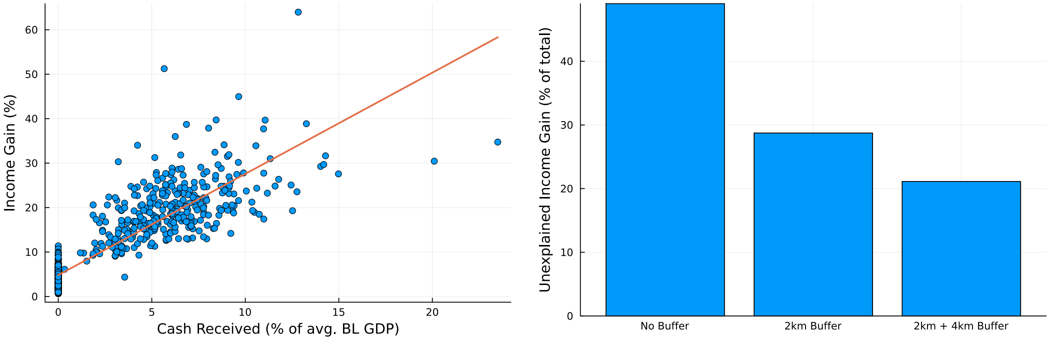
Mechanism: structural transformation (details)

→ Back



Missing Intercept on Village-Level GDP



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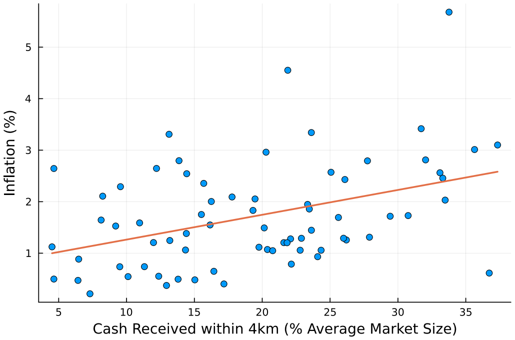
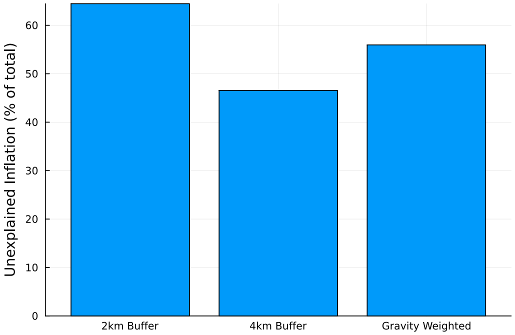
Missing Intercept on Market-Level Inflation





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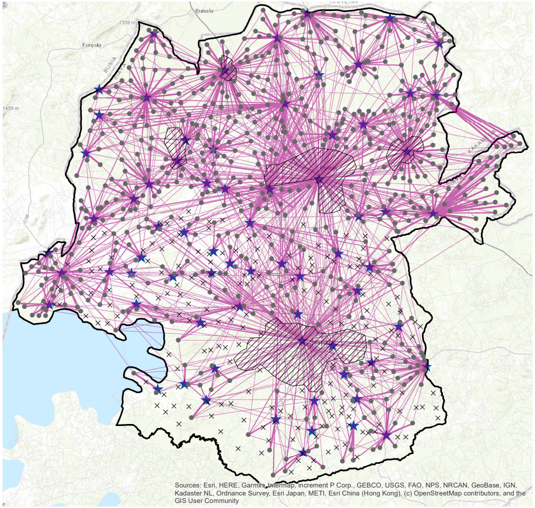
Gravity estimation. use household survey data on shopping patterns between markets to estimate

$$\log \pi_{vmt} = -\sigma\kappa \text{km}_{vm} + f_t + f_v + f_m$$

Results.

- Calibrate $\sigma = 4$ (price elasticity)
- $\widehat{\sigma\kappa} = 0.88 \implies \kappa = 0.22$

→ back



Structural transformation: details ⇒ back

	(1) Total Effect IV	(2) Control, low saturation mean (SD)
Individual hours worked	−2.75* (1.58)	32.30 (27.64)
Individual hours worked in agriculture	−3.33** (1.33)	20.12 (19.00)
Individual hours worked on own farm	−3.43*** (1.25)	18.33 (17.04)
Individual hours employed in agriculture	0.07 (0.35)	1.81 (7.49)
Individual hours worked not in agriculture	0.31 (1.03)	12.39 (22.15)
Individual hours worked in non-ag self-employment	−0.71 (0.74)	7.25 (17.03)
Individual hours employed not in agriculture	1.02* (0.59)	5.13 (16.35)
Share of hours spent on agricultural activities	−0.05* (0.02)	0.62 (0.37)