Spatial Risk-Sharing with Transfer Frictions

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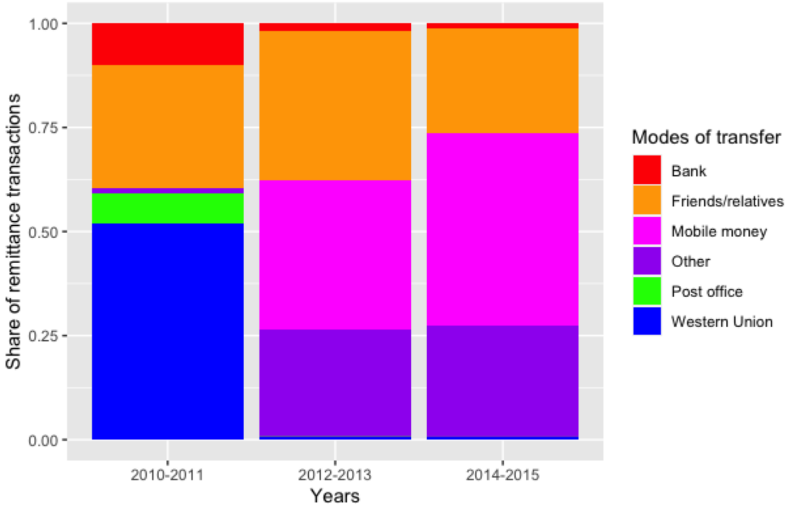
Introduction

- **Remittance networks** counter consumption volatility in developing countries
  - *Sparse:* in Tanzania, 84.4% of households receiving remittances report only *one* source
  - *Intra-familial:* 87.9% of reported sources are relatives

- In 2008, new availability of mobile money technologies constituted transfer friction shock
  - Mobile money substitutes for physical transport of money, facilitates network formation
  - Economides Jeziorski '17: WTP avoid walk with cash for an extra km is 1.25% transaction

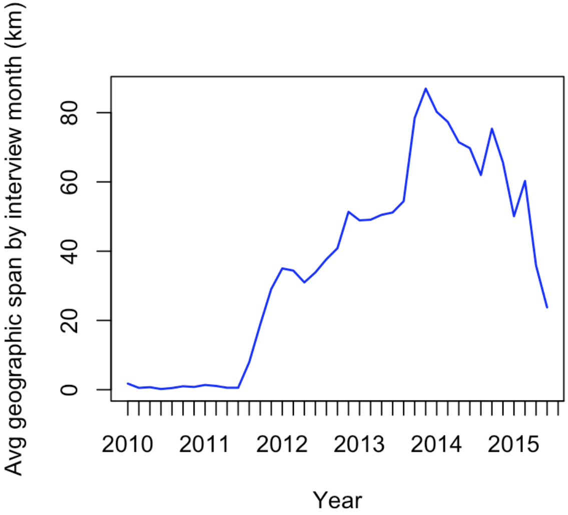
Introduction

Mobile money substituted, then dominated, other modes of remittance transfer



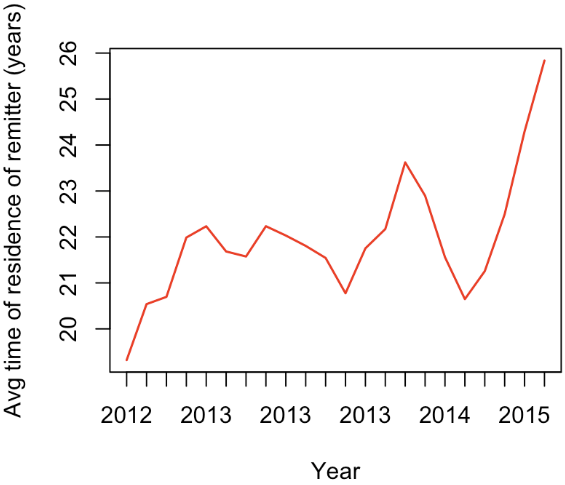
Introduction

The geographic span of remittance networks *grew* and became *more volatile*.



Introduction

Span fluctuations involve leveraging alternative relationships, *not* migration.



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- Question: How does mobile money impact the **geographic span** of remittance networks?

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  - What rationalizes fluctuations in span? Do these changes impact consumption volatility?
    - → Model of remittance demand featuring endogenous search & spatial correlation of shocks
    - → Generates predictions of span cyclicality supported in data

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  - What rationalizes fluctuations in span? Do these changes impact consumption volatility?
    - → Model of remittance demand featuring endogenous search & spatial correlation of shocks
    - → Generates predictions of span cyclicality supported in data
  - Mobile money adoption may increase consumption fluctuations
    - → As span increases, motives of *profiting* dominate motives of *smoothing*

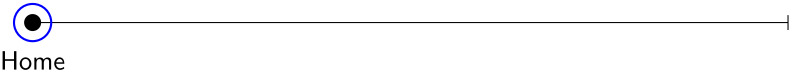
Roadmap

1. Model
2. Empirics

Roadmap

1. Model
2. Empirics

Illustration



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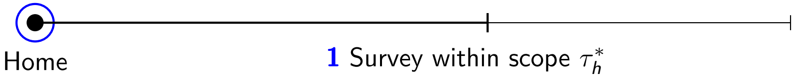

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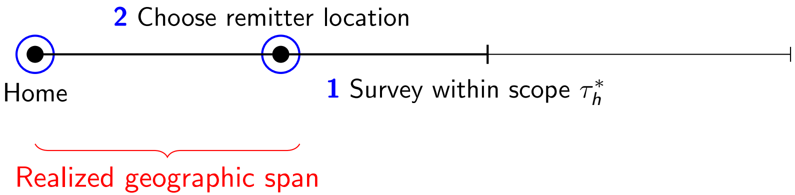

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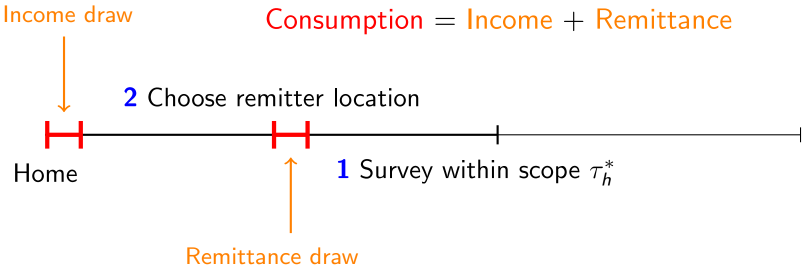

Productivity over geography

- Geographic productivity draw for location τ-distance away from home 0:

$$W_\tau = w\sigma \left(B_\tau - \int_0^1 B_j dj + \frac{1}{\sigma} \right)$$

  - B_τ is a Brownian bridge
  - w average productivity, σ dictates productivity volatility
  - Adapted from Gârleanu, Panageas, & Yu (2015)

- Helpful properties of geographic productivity process:
  1. Identical marginal distribution of $W_\tau, \forall \tau \Rightarrow$ no arbitrage
  2. Decreasing covariance with greater distance $\Rightarrow$ embedded spatial correlation

Empirical spatial correlation

Endogenous survey scope

- Survey scope choice:

$$\tau_h^* = \arg\max_{\tau \in [0,1]} \mathbb{E}\left[U\Big(C_h(\tau) - S(\tau)\Big)\right]$$

  - $C_h(\tau)$ consumption r.v. given search scope τ and household h's characteristics
    - $\rightarrow$ Sources of uncertainty: geographic productivity, household-location productivity
    - $\rightarrow$ Consumption = Income + Remittance, $C_h(\tau) = \zeta I_h(\tau) + (1-\zeta) R_h(\tau)$ for $\zeta < 1$
  - $S(\tau)$ convex survey costs

- Households balance marginal expected utility gains with survey costs

$$\frac{\partial \mathbb{E}[C_h(\tau)]}{\partial \tau} + \frac{1}{\chi - 1} \frac{\partial \mathbb{V}[C_h(\tau)]}{\partial \tau} = \frac{\partial S(\tau)}{\partial \tau}, \text{ where } \chi = \frac{2U'(\mathbb{E}[C_h(\tau) - S(\tau)])}{U'''(\mathbb{E}[C_h(\tau) - S(\tau)])}$$

  - τ_h^* unique for sufficiently convex S

Remitter location choice

- Given home 0, households remit from location

$$\arg \max_{x\in\{0,\epsilon,2\epsilon\ldots,\tau\}} \left\{ I_{hx0} = \left(\int_{x}^{x+\epsilon} I_{hi} di \right) /\epsilon \right\}$$

- The income draw is distributed Exponential with stochastic shape parameter $\bar{z}_h \Phi_\tau$

$$F(I_{hi}(\tau)) = 1 - \exp\left(- \frac{I_{hi}}{\bar{z}_h \Phi_\tau} \right), \forall i \in [0,1]$$

  - Household productivity $\bar{z}_h$
  - Stochastic remittance access $\Phi_\tau = (\int_0^\tau W_i / [d(i,0)+1]^\delta di)$
    - $\rightarrow$ Distance metric $d(i,0) = \min(i, 1-i)$
    - $\rightarrow$ Severity of transfer friction δ
  - Income distribution: $I_h(\tau) = I_{h0}(\tau)$

Calculating expected remittances

- Limiting c.d.f. of remittance distribution,

$$R_h(\tau) = \lim_{\epsilon \to 0} \max_x \underbrace{G_{hx}(W|\tau)}_{\text{Location wage draw c.d.f.}} = \exp\left(-\exp\left(-\frac{W}{\bar{z}_h \Phi_\tau}\right)\right)$$

  - Gumbel-distributed with stochastic scale parameter
    - → Conditional expectation: $\mathbb{E}[R_h(\tau)|\Phi_\tau] = \bar{z}_h \Phi_\tau \gamma$, where γ Euler constant
    - → Conditional variance: $\mathbb{V}[R_h(\tau)|\Phi_\tau] = \frac{\pi^2}{6} \bar{z}_h^2 \Phi_\tau^2$

- Limiting probability that span $< \tilde{\tau}$ given search scope τ,

$$\pi_0(\tilde{\tau}|\tau) = \frac{\exp(\Phi_{\tilde{\tau}})}{\exp(\Phi_{\tilde{\tau}}) + \exp(\Phi_\tau - \Phi_{\tilde{\tau}})}, \text{ for } \tilde{\tau} < \tau$$

Remittance access properties

Proposition. *Profiting and smoothing through scope*

Suppose $\tau \in [0,1]$ and normalize $\sigma^2 = 1$. Consider remittance access, Φ_τ.

(a) The mean increases in search scope, $\frac{\partial \mathbb{E}(\Phi_\tau)}{\partial \tau} > 0$, and the increase becomes more pronounced as transfer frictions decline, $\frac{\partial^2 \mathbb{E}(\Phi_\tau)}{\partial \tau \partial \delta} < 0$.

(b) The variance decreases in search scope, $\frac{\partial \mathbb{V}(\Phi_\tau)}{\partial \tau} < 0$, and the decrease becomes more pronounced as transfer frictions decline, $\frac{\partial^2 \mathbb{V}(\Phi_\tau)}{\partial \tau \partial \delta} > 0$.

Profiting and δ Smoothing and δ

Consumption properties

Proposition. *Linking consumption and remittance access*

Suppose $\tau \in [0,1]$, and normalize $\sigma^2 = 1$. Suppose $\bar{z}_h$ is constant. Consider consumption conditional on search scope τ, $C_h(\tau)$. Then,

$$\mathbb{E}[C_h(\tau)] = \bar{z}_h \mathbb{E}(\Phi_\tau)[(1-\zeta)\gamma + \zeta]$$

and

$$\mathbb{V}[C_h(\tau)] = \alpha \cdot \mathbb{E}(\Phi_\tau)^2 + \beta \cdot \mathbb{V}(\Phi_\tau),$$

where

$$\alpha = \bar{z}_h^2 \left(\frac{\pi^2}{6}(1-\zeta)^2 + (1+2e^{-\Phi_\tau})\zeta^2 \right) \text{ and } \beta = \bar{z}_h^2 \left(\left(\frac{\pi^2}{6} + \gamma^2 \right)(1-\zeta)^2 + (1+2e^{-\Phi_\tau})\zeta^2 \right).$$

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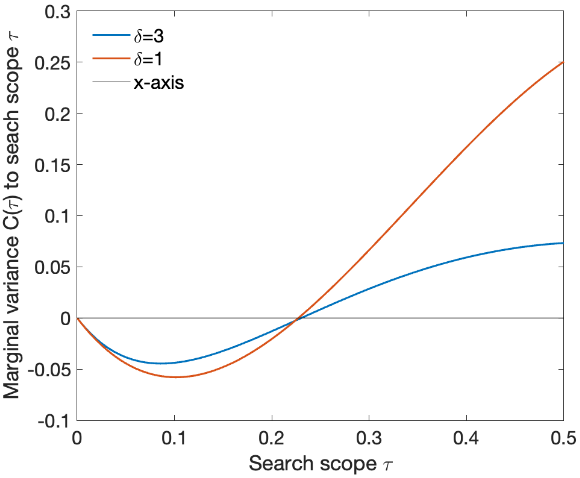
- Comparative statics $\Rightarrow$ optimal search scope τ^* larger after mobile money adoption
- Relatively high β $\Rightarrow$ higher search scope τ lowers consumption fluctuations

Under stochastic $\bar{z}$

Mobile money adoption *increases* consumption fluctuations

- When "profiting" dominates "smoothing" for some search scope ($\alpha = 1, \beta = 1.5$):



Geographic span under aggregate fluctuations

Proposition. *Cyclicality of geographic span*

Consider Φ_ϵ for $\epsilon \to 0$, s.t. $\lim_{\epsilon \to 0} \Phi_\epsilon / \epsilon = W_0$.

The probability of span $> \tilde{\tau}$ under optimal search scope is countercyclical, $\frac{\partial \pi_0^{-1}(\tilde{\tau})}{\partial \Phi_\epsilon} < 0$.

The extent of countercyclicality declines with reductions in transfer friction convexity, $\frac{\partial^2 \pi_0^{-1}(\tilde{\tau})}{\partial \Phi_\epsilon \partial \delta} < 0$.

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- δ changes household response of span to aggregate conditions
  - Lower δ, *profiting* dominates *smoothing* $\Rightarrow$ lowered home bias makes far locations palatable
  - Geographic span is *less* countercyclical for adopters than non-adopters
- Networks facilitate smoothing against geographic shocks thru increased span
  - Mobile money lowers response $\Rightarrow$ *Increases* consumption fluctuations

Under stochastic $\bar{z}$

Roadmap

1. Model
2. Empirics

Model predictions

1. Geographic span increases after mobile money adoption

2. Higher geographic span lowers consumption fluctuations

3. Geographic span is *less* countercyclical for adopters than non-adopters

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1. Geographic span increases after mobile money adoption
2. Higher geographic span lowers consumption fluctuations
3. Geographic span is *less* countercyclical for adopters than non-adopters

- Data: Tanzania National Panel Survey (NPS) follows 14,985 households
  - Round 1, 2008/09; 2, 2010/11; 3, 2012/13; 4, 2014/15
  - *Total consumption* = Remittances + Wage income + Business profits + Transfers

2 Higher geographic span lowers consumption fluctuations

- 81% of households in NPS report negative shocks
- Consider regression for household h, region i, time t

$$\underbrace{y_{hit}}_{\text{Total consumption}} = \alpha + \beta \cdot Shock_{hit} + \xi \cdot \underbrace{Span_{hit}}_{\text{Instrument with } Z_{hit}} + \phi \cdot \underbrace{(Shock_{hit} \times Span_{hit})}_{\text{Instrument with } Shock_{hit} \times Z_{hit}}$$

$$+\Gamma' X_{hit} + \gamma_i + \gamma_t + \epsilon_{hit}$$

  - Theory implies $\boldsymbol{\beta < 0}$ and $\boldsymbol{\phi > 0}$

- **Exclusion restriction:** Z_{hit} influences y_{hit} only through $Span_{hit}$, not through ϵ_{hit}
  - Variation in mobile money adoption *costs*—includes information frictions, tech savviness
  - Z_{hit} is a Bartik instrument More
    - $\rightarrow$ Shares: age-decile share of co-locating villagers, Shifts: national adoption rate for age decile

2 Higher geographic span lowers consumption fluctuations

	Total consumption (100,000s TZS)			
	All households		*Only remitters*	
	OLS	IV	OLS	IV
Shock	-14.95 (6.820)**	-37.64 (12.31)**	-2.623 (16.21)	-40.26 (18.57)**
Span	0.048 (0.026)*	-0.884 (0.267)**	0.080 (0.068)	-0.561 (0.264)**
Span × Shock	-0.085 (0.058)	1.019 (0.302)**	-0.192 (0.081)**	0.703 (0.348)**
Observations	15,742	15,742	4,218	4,218
F-stat, Span		153.9		58.51
F-stat, Span × Shock		152.8		60.46

Notes: ** denotes significance at the 5% level. The table shows regression coefficients. Huber-White robust standard errors clustered at the ward-level are in parentheses. Controls include HH characteristics, village characteristics, region f.e., and round f.e.

3 Geographic span is *less* countercyclical for adopters than non-adopters

- "Cycles" = fluctuations in *local* economic conditions
  - 14.8% of shocks impact "all households" in a community Types of aggregate shocks

- Consider regression for household h, region i, round t

$$Span_{hit} = \alpha + \beta \cdot AShock_{hit} + \delta \cdot \underbrace{MM_{hit}}_{\text{Instrument with } Z_{hit}} + \zeta \cdot \underbrace{(AShock_{hit} \times MM_{hit})}_{\text{Instrument with } AShock_{hit} \times Z_{hit}}$$

$$+\Gamma' X_{hit} + \gamma_t + \gamma_i + \epsilon_{hit}$$

  - ζ is difference in remittance radius cyclicality for adopters vs. non-adopters
    $\rightarrow$ Theory implies $\boldsymbol{\beta > 0}$ and $\boldsymbol{\zeta < 0}$

3 Geographic span is *less* countercyclical for adopters than non-adopters

	Geographic span (km)	
	OLS	IV
Aggregate shock	2.915 (1.887)	10.74 (2.795)**
MM part.	56.56 (34.40)**	84.93 (5.441)**
Aggregate shock × MM part.	8.526 (8.580)	-44.22 (19.41)**
Observations	15,116	15,116
F-stat, MM part.		100.4
F-stat, Aggregate shock × MM part.		110.6

Notes: ** denotes significance at the 5% level. The table shows regression coefficients. Huber-White robust standard errors clustered at the ward-level are in parentheses. Controls include HH characteristics, village characteristics, region f.e., and round f.e.

Conclusions

- Spatial diversification of remittance networks promotes consumption-smoothing
  - But span is endogenous, fluctuates systematically with household & location conditions

- I incorporate a realistic geographic shock structure into a spatial model
  - Consumption fluctuations reflect both motives of *profiting* and *smoothing*
    - → Mobile money may *increase* consumption fluctuations under higher search scope

- Do new technologies reduce consumption lumpiness? Maybe not.
  - Movements in geographic span largely characterized by motives of smoothing
    - → But less so when transfer frictions decline
    - → Empirically, countercyclical span for non-adopters, procyclical for adopters
  - Endogenous search links times of lower consumption with less remittance diversification
    - → Link tightens when transfer friction decline
    - → Empirically, adopters contract span *more* than non-adopters after negative shocks

Thank you!

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IV endogeneity

- Concern: Ward-specific components of adoption changes and ϵ_{hit}
  - Examples of concerns:
    - → Broadband (NICTBB) increases HH tech access *while* enhancing market integration
    - → HHs in flooded regions adopt to receive aid
    - → HHs experiencing good harvests adopt to remit surplus
  - Solution: *Use of national, not regional, "shifts"*

- Concern: With local insurance, HHs depress income to avoid sharing with neighbors
  - Solution: *Include ward-average income, remittance radius, # transfer sources in first-stage*

- Concern: HHs select into adoption
  - Solution: *Include HH characteristics in first-stage*

- Concern: Correlation of HH unobservables after long-run sorting
  - Low # permanent movers in 2010-2015, ≈ 3.59% of HHs
  - Only small differences in mean age of movers and non-movers

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Exogenous IV variation

- Age distribution of HH heads embed historic, ward-specific shocks to mortality
  - *E.g.*, TZ HIV epidemic is "generalized" with "concentrated sub-epidemics" (USAID, 2016)
- $\uparrow$ HIV regional prop. significantly linked $\downarrow$ middle-aged, $\uparrow$ young HH heads
- In 1983, epidemic first identified in Bukoba regional hospital in Kagera region
  - Result from increased mobility after TZ-Uganda war
    - $\rightarrow$ Distance to Uganda negatively determines HH age distribution
  - Age distribution in other regions stochastically dominate those in Uganda-adjacent regions

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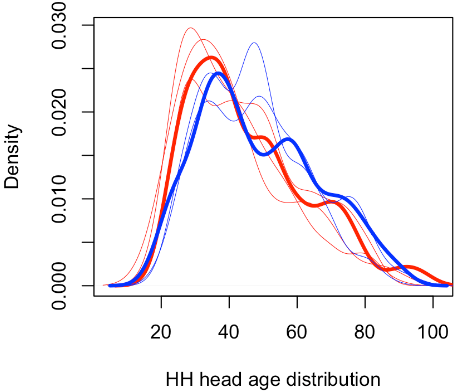
Exogenous IV variation



Notes: The bolded red line refers to age distribution of Kagera, only region neighboring Uganda. Thin red lines refer regions neighboring Kagera (i.e., Kigoma, Geita, Mwanza). The bolded blue line refers to Mtwara, the geographic opposite of Kagera. Thin blue lines refer to regions neighboring Mtwara (i.e., Lindi and Ruvuma).

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Estimation of Borjas's positive selection condition

	$\widehat{\frac{\sigma_a}{\sigma_n}}$	$\widehat{\frac{\sigma_{an}}{\sigma_a \sigma_n}}$	$\widehat{\frac{\sigma_n}{\sigma_a}}$
Estimates	1.001	0.999	0.998

- σ_a, σ_n are variance of errors for adopt vs. non-adopt value functions
  - σ_{an} correlation of errors

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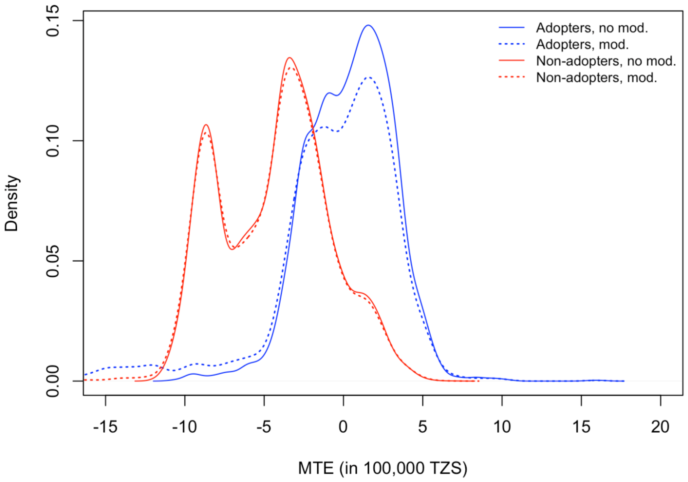
Impact of span on mobile money adoption gains



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Tanzania vs. Senegal

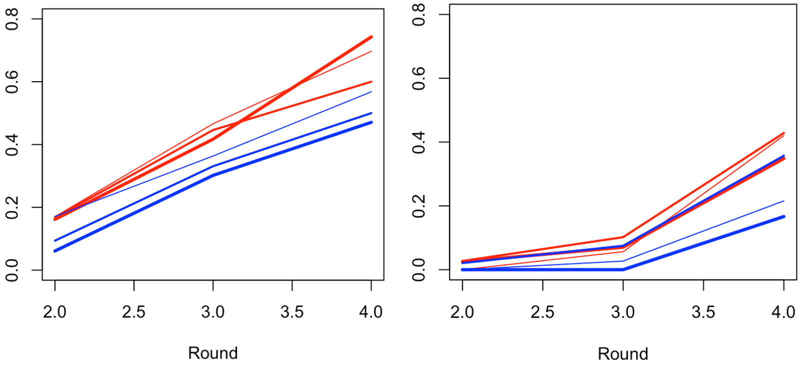

Figure: Tanzania (left) vs. Senegal (right) adoption shifts by age decile.

Notes. Red lines correspond to lowest three age deciles, blue lines correspond to highest three deciles. Wider lines correspond to more extreme deciles.

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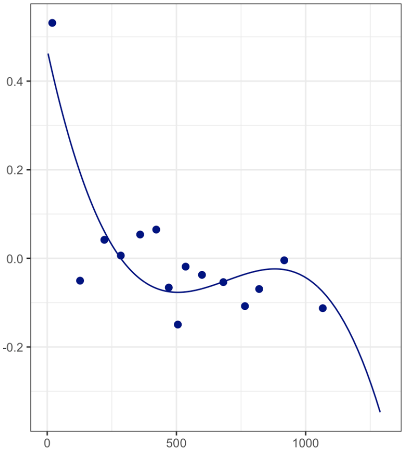
Empirical spatial correlation



Correlation of regional mean total wage income ($y-$axis) vs. Distance between regions ($x-$axis)

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Types of idiosyncratic shocks

Rank by frequency	*Type*	*Share*
1	Death of family member	29.58%
2	Death of household member	14.33%
3	Livestock died or were stolen	10.97%
4	Hijacking/robbery/burglary/assault	9.02%
5	Chronic illness of household member	8.91%

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Types of aggregate shocks

Rank by frequency	*Type*	*Share*
1	Large rise in price of food	40.27%
2	Severe water shortage	20.93%
3	Drought or floods	13.61%
4	Large fall in sale prices for crops	8.83%
5	Large rise in agricultural input prices	7.25%

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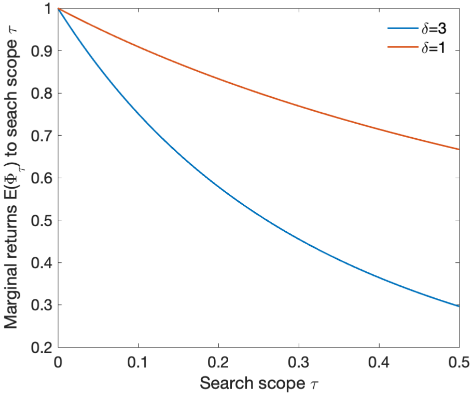
Profiting and transfer frictions: $\frac{\partial \mathbb{E}(\Phi_\tau)}{\partial \tau}$ and δ



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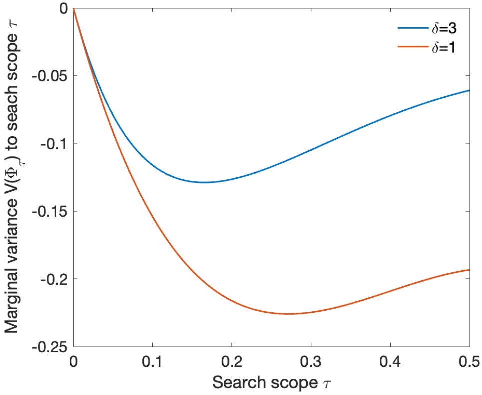
Smoothing and transfer frictions: $\frac{\partial \mathbb{V}(\Phi_\tau)}{\partial \tau}$ and δ



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Geographic span under stochastic productivity

Proposition. *Productivity fluctuations and geographic span*

Consider the probability of span $> \tilde{\tau}$ under optimal search scope, $\pi_0^{-1}(\tilde{\tau})$.

This probability increases in household productivity, $\frac{\partial \pi_0^{-1}(\tilde{\tau})}{\partial \bar{z}_h} > 0$.

If $|\frac{\partial^2 \Phi_{\tau^*}}{\partial \bar{z}_h \partial \delta}| \gg 0$, the extent of increase decreases with transfer friction convexity, $\frac{\partial^2 \pi_0^{-1}(\tilde{\tau})}{\partial \bar{z}_h \partial \delta} < 0$.

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If $\left|\frac{\partial^2 \Phi_{\tau^*}}{\partial \bar{z}_h \partial \delta}\right| \gg 0$, the extent of increase decreases with transfer friction convexity, $\frac{\partial^2 \pi_0^{-1}(\tilde{\tau})}{\partial \bar{z}_h \partial \delta} < 0$.

- **Channel:** $\bar{z}_h \downarrow \Rightarrow$ Endogenous decrease of search scope $\tau^* \Rightarrow$ Span $\downarrow$
  - Less transfer frictions δ reduce role of distance in determining τ^*
- Proposition links low expected consumption with low network diversification (i.e., high risk)
  - Mobile money exacerbates this relationship $\Rightarrow$ *Increases* consumption fluctuations
  - Adopters contract geographic span *more* than non-adopters after productivity dips

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Consumption fluctuations under stochastic productivity

Proposition. *Productivity fluctuations and weights*

(a) Suppose productivity $\bar{z}_h \sim \mathcal{N}(\hat{z}_h, \tilde{\sigma})$. Then, the variance of consumption conditional on search scope τ is

$$\mathbb{V}[C_h(\tau)] = \alpha \cdot \mathbb{E}(\Phi_\tau)^2 + \beta \cdot \mathbb{V}(\Phi_\tau),$$

where

$$\alpha = \left(\frac{\pi^2}{6} + \gamma^2\right)\tilde{\sigma}^2 + \frac{\pi^2}{6}\hat{z}_h^2 \text{ and } \beta = \left(\frac{\pi^2}{6} + \gamma^2\right)\tilde{\sigma}^2 + \left(\frac{\pi^2}{6} + \gamma^2\right)\hat{z}_h^2.$$

(b) Relative weights, $\hat{\alpha} = \frac{\alpha}{\alpha+\beta}$ and $\hat{\beta} = \frac{\alpha}{\alpha+\beta}$, vary with the productivity process. Specifically, $\frac{\partial\hat{\alpha}}{\partial\tilde{\sigma}^2} > 0$ and $\frac{\partial\hat{\alpha}}{\partial\bar{z}_h} < 0$ (and consequently, $\frac{\partial\hat{\beta}}{\partial\tilde{\sigma}^2} < 0$ and $\frac{\partial\hat{\beta}}{\partial\bar{z}_h} > 0$).

- Noisier process induces higher relative weight on "profiting" motive
- Productive process induces higher relative weight on "smoothing" motive

Back

IV for geographic span

- Bartik-style instrument for household h in village i at round t,

$$Z_{hit} = \sum_{k=1}^{10} s_{ki1,-h} \Delta \overline{MM}_{kt}$$

Endogeneity | Exogenous IV variation | Senegalese vs. Tanzanian shifts

  - $s_{ki1,-h}$, leave-one-out share of households in village i of kth age decile during round 1
  - $\Delta \overline{MM}_{kt}$ national adoption rate at round t for those in kth age decile range in Senegal
    - $\rightarrow$ Aggregated from 2011, 2014, & 2017 micro-data in Global Findex survey
  - **Intuition:** "I adopt when I am around young people, who know the latest apps to download"

- Why Senegalese "shifts"?
  - Senegal deployment patterns matches that of Tanzania $\Rightarrow$ Similar supply-side
  - Picks up common tech and work norms, not Tanzania-specific economic environment

Back

Related Literature

1. Risk-sharing networks in developing countries
   - Village: Townsend (1994); Udry (1994); Kocherlakota (1996); Ligon (1998); Ligon, Thomas, & Worrall (2002); Attanasio & Rios-Rull (2000); Chiapporietla (2014); Samphantharak & Townsend (2018); Morten (2019); Brooks & Donovan (2020); Ambrus, Gao, & Milán (2022)
   - Temporary migration: Rosenzweig (1978); Jayachandran (2005); Topalova (2010); Munshi & Rosenzweig (2013, 2016); Meghir, Mobarak, Mommaerts, & Morten (2022); Lagakos, Mobarak, & Waugh (2022); Bryan, Chowdury & Mobarak (2014); Akram, Chowdury, & Mobarak (2017)
   - Borrowing & loans: Banarjee & Duflo, 2010; Stephens & Barrett (2011); Basu & Wong; Mobarak & Rosenzweig (2012, 2013); Crepon, Devoto, Duflo, & Pariente (2015); Burke, Bergquist, & Miguel (2019); Sripakdeevong & Townsend (2019)
   - Remittances: Yang (2008); Jack, Ray, & Suri (2013); Joseph, Nyarko, & Wang (2018); Dupas, Karlan, Robinson & Ubfal (2018); Munyegara & Matsumoto (2016); Riley (2018); Batista & Vicente (2020); Caballero, Cadena, & Kovak (2021)
   - Contribution: *Endogenize geographic span as a key determinant of risk-sharing effectiveness*

2. Volatility and uncertainty in space
   - van Wincoop (1999); Clark & van Wincoop (2000); di Giovanni & Levchenko (2009); Burgess & Donaldson (2012); Ambrus, Mobius, & Szeidl (2014); Gârleanu, Panageas, & Yu (2015); Allen & Atkin (2016); Caselli, Koren, Lisicky, & Tenreyo (2015)
   - Contribution: *Include geographic uncertainty in spatial models*