Spatial Spillovers and Labor Market Dynamics: Village Financial Interventions in Thailand

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Motivation

How does one evaluate the general equilibrium, macro effects of scaled-up village-level RCTs and interventions?

Yale Research Initiative on Innovation and Scale: "While evaluation techniques for pilot-scale programs are well developed, complexities arise when we contemplate scaling up interventions to create policy change."

Conceptual Framework:

- Previous Literature: using micro RCT data embedded in macro models to compute general equilibrium counterfactuals (e.g. Buera Kaboski and Shin 2017)
- Why can't we use the approach in the previous literature? With imperfect labor markets, cannot jump to frictionless GE. In developing countries, such frictions abound - Buera, Kaboski, and Townsend (2018).
- Our Approach: document and understand the effects of an already scaled-up program

Preview of Results

What we find in Thai village census data:

- Own credit effect on village level wages
- Interesting wage dynamics, over time
- Spillovers from neighboring villages
- Greater impact of own-effect on more isolated villages

Tension: retain what we know of within village economies but aggregate up to get market clearing wages that allows these with spatial patterns.

Program Overview

Thailand's "Million Baht Village Fund" program:

- Created village banks in almost 80,000 villages in 2002
- 1.5% of Thailand's GDP
- Each bank was endowed with 1 million Baht (around $24,000) $\rightarrow$ quasi-natural variation in credit per household at the village level
- Village size is exogenous
- Program was unexpected

Within Village Effects of Micro Finance

What we know and distinguishing short run and long-run.
Kaboski and Townsend (2012):

- Increased total short-term credit, consumption, agricultural investment, and income growth but decreased overall asset growth
- Increased wages
- Not a statistically significant effect on occupation

Fulford (2011), India, bank placement:

- Initial boom in consumption and poverty reduction; eventual decrease in consumption, rise in poverty

Banerjee, Breza, Duflo and Kinnan (2015):

- 6 years out, benefits for pre-existing "gung-ho entrepreneur", but not "reluctant entrepreneurs"

Initial Structural Models

Kaboski and Townsend (2011)'s model includes:

- Precautionary liquid savings to smooth uninsured income shocks (will be included in our model)
- Limited borrowing due to financing constraints, as a function of permanent income (constraints key in our model)
- Investment which is discrete with stochastic opportunities, common real return (investment smooth in our model)

New ingredients and results not in original models

Banerjee, Breza, Townsend, and Vera-Cossio (2018):

- Large heterogeneity in terms of underlying household productivity
- TFP estimated with pre-intervention data
- Large increase post intervention in profits, and assets used in production, especially non-agriculture business, but not for the lower quartiles of productivity
- Our model has TFP heterogeneity as key ingredient across villages (and will be also within)

Pawasutipaisit and Townsend (2011), Samphantharak and Townsend (2017):

- Average returns are highly persistent over time (our model allows for this, TFP currently fixed)

Village committee did not allocate funds by productivity (our model does not encompass this)

Alternative Commodity Spaces

Paweenawat and Townsend (2018):

- Documented villages more open to capital than labor (we keep this)
- Multiple goods and trade

Breza and Kinnan (2018):

- Multiple goods, tradable and non-tradable

Our model has one good. Documenting commodity output, consumption, and input flows in Thailand:

- Burstein, Hanson, Tian, and Vogel (2018): prices respond more in non-tradable than tradable sectors to immigration
- Most goods at the village level are tradable - Paweenawat and Townsend (2018)
- Also Paweenawat and Townsend (2018): no responses in village imports and exports due to Village Fund

Across Village Perspective, Effects of Micro Finance

Bryan, Chowdhury and Mobarak (2017):

- Migration subsidy $\rightarrow$ outflow of labor
- Increased wages for those left in village (big part of our model)

Lagakos, Waugh, Mubarak (2018):

- Substantial gains to migration for the low income, low asset households (also in our model)

Data

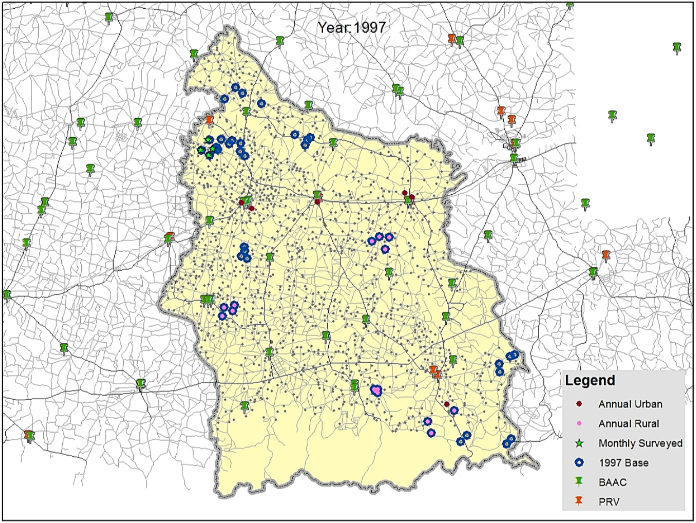
Thailand's Community Development Department (CDD) panel:

- Bi-annual village-level survey 1986 - 2011
- Includes average village daily wages and village population
- Measurement error in population levels
- Does not have data on migration flows between villages

GIS data of Thailand's road network:

- Used to construct buffer zones using travel time and travel distance

Figure: Map of Villages and Road Network



Result 1: Baseline effect of Credit on Wages

We run the reduced form regression

$$y_{it} = \beta \text{Credit}_i * \text{Post}_t + \phi_i + \phi_t + \epsilon_{it} \quad (1)$$

where

- y_{it} is wage in village i at time t
- Credit_i is equivalent to $100/NoHouseholds_{i,2001}$, the inverse of the number of households in village i in 2001
- Post_t is a dummy equal to 1 if $t \geq 2003$
- ϕ_i is the village fixed effect
- ϕ_t is the time fixed effect

Result 1

Table: Microfinance and Wages Baseline

VARIABLES	(1) Wage	(2) Wage	(3) Wage	(4) Log Wage	(5) Log Wage	(6) Log Wage
$\text{Credit}_i * \text{Post}$	1.495***	1.508***	1.195***	0.00997***	0.0114***	0.00996***
	(0.221)	(0.202)	(0.176)	(0.00197)	(0.00140)	(0.00121)
Constant	38.70***			3.587***		
	(0.187)			(0.00280)		
Observations	432,783	432,783	432,783	432,783	432,783	432,783
R^2	0.790	0.831	0.851	0.861	0.894	0.906
Number of Villages	39,628			39,628		
Year FE	YES	NO	NO	YES	NO	NO
Village FE	YES	YES	YES	YES	YES	YES
Prov-yr FE	NO	YES	NO	NO	YES	NO
Amphoe-yr FE	NO	NO	YES	NO	NO	YES
Drop Outliers	YES	YES	YES	YES	YES	YES

This table reports the results of equation 4 on wages. Standard errors clustered at tambon-level throughout.

*** p<0.01, ** p<0.05, * p<0.1

Result 2: Dynamic effect of Credit on Wages

We run the regression

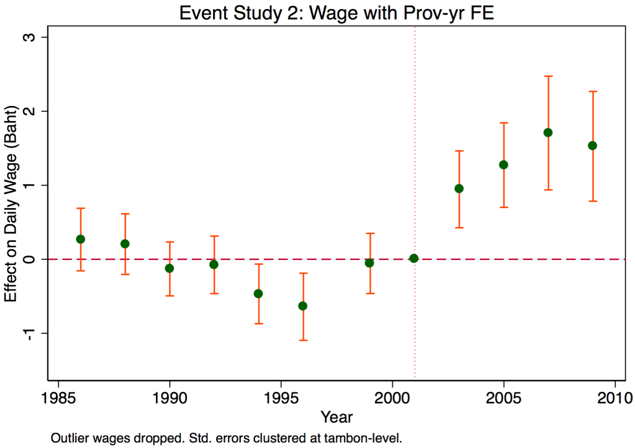
$$y_{it} = \sum_{t=1986}^{2009} \beta_t \text{Credit}_i * \phi_t + \phi_i + \epsilon_{it} \tag{2}$$

where

- Credit_i is interacted with the time effect

Result 2

Figure: Event Study of Credit on Wages with Prov-yr FE



Result 3: Effect of Credit Spillovers on Wages

We capture spatial spillovers by modifying the baseline specification to

$$y_{it} = \beta \text{Credit}_i * \text{Post}_t + \gamma \text{NeighborCredit}_{r,i} * \text{Post}_t + \phi_i + \phi_t + \epsilon_{it} \quad (3)$$

where

- $\text{NeighborCredit}_{r,i}$ is a spatial kernel estimate of the inverse of the number of households in villages within radius r km of village i in 2001
- Kernel is the inverse of the average village population within a buffer zone of radius r. Can weight the village populations by distance.
- Results robust in r, including $r = 3, 5$ km
- All other terms defined as earlier
- Population migrates out of village i

Result 3

Table: Spillovers where $r = 5$ km

VARIABLES	(1) Wage	(2) Wage	(3) Wage	(4) Log Wage	(5) Log Wage	(6) Log Wage
$\text{Credit}_i * \text{Post}$	0.913***	1.060***	1.110***	-0.00106	0.00739***	0.00853***
	(0.191)	(0.186)	(0.175)	(0.00174)	(0.00130)	(0.00121)
$\text{NeighborCredit}_{5,i} * \text{Post}$	3.238***	3.242***	0.955	0.0623***	0.0289***	0.0161**
	(0.991)	(1.054)	(1.042)	(0.00928)	(0.00757)	(0.00703)
Constant	38.70***			3.587***		
	(0.187)			(0.00280)		
Observations	432,252	432,252	432,252	432,252	432,252	432,252
R^2	0.790	0.831	0.851	0.861	0.894	0.906
Number of Villages	39,579			39,579		
Year FE	YES	NO	NO	YES	NO	NO
Village FE	YES	YES	YES	YES	YES	YES
Prov-yr FE	NO	YES	NO	NO	YES	NO
Amphoe-yr FE	NO	NO	YES	NO	NO	YES
Drop Outliers	YES	YES	YES	YES	YES	YES

This table reports the results of equation 3 on wages. Standard errors clustered at tambon-level throughout.

*** p<0.01, ** p<0.05, * p<0.1

Quadratic Time Trend

We run the regression

$$y_{it} = \beta \text{Credit}_i * \text{Post}_t + \text{NeighborCredit}_{r,i} * \Delta\text{t} + \text{NeighborCredit}_{r,i} * \Delta\text{t}^2 + \phi_i + \phi_t + \epsilon_{it} \quad (4)$$

where

- Δt is the difference between the year and 2002 if $t > 2002$ and 0 if $t \leq 2002$
- Δt^2 is the difference squared

Quadratic Time Trend

Table: Quadratic Time Trend

VARIABLES	(1) Wage	(2) Wage	(3) Wage	(4) Log Wage	(5) Log Wage	(6) Log Wage
$\text{Credit}_i * \text{Post}$	1.008***	1.086***	1.088***	0.000772	0.00786***	0.00858***
	(0.187)	(0.183)	(0.171)	(0.00169)	(0.00128)	(0.00119)
$\text{NeighborCredit}_{5,i} * \Delta t$	2.145***	1.856***	0.431	0.0351***	0.0170***	0.00746
	(0.599)	(0.668)	(0.705)	(0.00512)	(0.00454)	(0.00463)
$\text{NeighborCredit}_{5,i} * \Delta t^2$	-0.280***	-0.207**	-0.0240	-0.00421***	-0.00203***	-0.000672
	(0.0844)	(0.0977)	(0.109)	(0.000635)	(0.000621)	(0.000668)
Constant	38.72***			3.587***		
	(0.187)			(0.00280)		
Observations	431,913	431,913	431,913	431,913	431,913	431,913
R^2	0.790	0.831	0.851	0.861	0.894	0.906
Number of newvill8	39,544			39,544		
Year FE	YES	NO	NO	YES	NO	NO
Village FE	YES	YES	YES	YES	YES	YES
Prov-yr FE	NO	YES	NO	NO	YES	NO
Amphoe-yr FE	NO	NO	YES	NO	NO	YES
Drop Outliers	YES	YES	YES	YES	YES	YES

Standard errors clustered at tambon-level throughout.

*** p<0.01, ** p<0.05, * p<0.1

Result 4: Effect of Isolation on Spillovers

We run the following regression

$$y_{it} = \beta \text{Credit}_i * \text{Post}_t + \theta \text{Credit}_i * \text{Post}_t * \text{Isol}_i + \phi_i + \phi_t + \epsilon_{it} \quad (5)$$

where

- Isol_i is a measure of the isolation of a village
- Define isolation several ways, including: distance to nearest village, dummy for whether the distance to the nearest village is greater than some percentile in the distribution
- Robust to all definitions of isolation
- Fewer people migrate into village i

Result 4

Table: Isolation

VARIABLES	(1) Wage	(2) Wage	(3) Wage	(4) Log Wage	(5) Log Wage	(6) Log Wage
$\text{Credit}_i * \text{Post}$	0.842***	1.270***	0.889***	0.00367	0.00345*	0.00546***
	(0.321)	(0.289)	(0.259)	(0.00294)	(0.00199)	(0.00180)
$\text{Isol}_i * \text{Post}$	0.867***	0.306	0.402*	0.00841***	0.0104***	0.00592***
	(0.288)	(0.260)	(0.236)	(0.00260)	(0.00184)	(0.00166)
Constant	38.71***			3.587***		
	(0.187)			(0.00280)		
Observations	432,165	432,165	432,165	432,165	432,165	432,165
R^2	0.790	0.831	0.851	0.861	0.894	0.906
Number of Villages	39,569			39,569		
Year FE	YES	NO	NO	YES	NO	NO
Village FE	YES	YES	YES	YES	YES	YES
Prov-yr FE	NO	YES	NO	NO	YES	NO
Amphoe-yr FE	NO	NO	YES	NO	NO	YES
Drop Outliers	YES	YES	YES	YES	YES	YES

This table reports the results of equation 4 on wages. Standard errors clustered at tambon-level throughout.
*** p<0.01, ** p<0.05, * p<0.1

Baseline Model

Environment:

- $i = 1, ..., N$ villages
- Villages partially integrated in labor markets
- Discrete time
- Households either entrepreneurs e or workers w
- There is open economy interest rate $1 + r$
- The wage is endogenous
- Distribution of workers across villages and asset levels, $L_{it}^{w}(a)$.
- Distribution of entrepreneurs across asset levels, $L_{it}^{e}(a)$.

Worker Problem

- Continuum of workers
- Maximize lifetime utility
- Discount rate β
- Born with assets a_0 that differ by both worker and village $\rightarrow$ Villages have different populations and worker asset distributions
- Provide one unit of inelastic labor (Bonhomme et al 2014 find that wage elasticity for workers in Thailand is low and often insignificant)
- Can migrate from village i to j paying migration cost κ_{ij}

Worker Problem I

The recursive formulation of the worker problem is

$$V^w_{i,t}(a) = \max_{a' \geq -\bar{a}} \{u((1+r)a + w_{i,t} - a') + \mathrm{E}[\max_{j \in M}\{\beta V^w_{j,t+1}(a' - \kappa_{ij}) + \epsilon_{j,t}\}]\}$$

Assuming that the idiosyncratic shocks ϵ are iid and follow a Type-I Extreme Value Distribution, we can rewrite the value function to:

$$\begin{aligned} V^w_{i,t}(a) = \max_{a' \geq -\bar{a}} \{ & u((1+r)a + w_{i,t} - a') \\ & + \nu \log(\sum_{j \in M} (\exp(\beta V^w_{j,t+1}(a' - \kappa_{ij})))^{1/\nu})\} \end{aligned}$$

Worker Problem II

Let $g^w(i,a)$ be the worker's asset policy function. We then derive the migration shares, the fraction of workers who start period t with assets a in village i and move to j at the end of the period:

$$m_{ijt}(a) = \frac{(\exp(\beta V^w_{j,t+1}(g^w(i,a) - \kappa_{ij})))^{1/\nu}}{\sum_{m \in M}(\exp(\beta V^w_{m,t+1}(g^w(i,a) - \kappa_{im})))^{1/\nu}}$$

The distribution of workers across locations and assets evolves according to

$$L_{jt+1}(a'') = \sum_{i \in N} \int_{a: g^w(i,a) - \kappa_{ij} = a''} m_{ijt}(a) L_{it}(a) da$$

and the labor supply in each village is

$$L_{jt} = \int_a L_{jt}(a)$$

Entrepreneur Problem I

There is one representative firm per village.

The recursive formulation of the entrepreneur's problem is

$$V_i^e(a,z) = \max_{a' \geq -\bar{a}} \{u((1+r)a + \pi(a,z) - a') + \beta \mathrm{E}[V_i^e(a',z)]\}$$

where

$$\pi(a,z) = \max_{k,l} \{z(k^\alpha l^{1-\alpha})^{1-\gamma} - w_{i,t} l - rk\}$$
$$\text{s.t } k \leq \phi a$$

and $\alpha, \gamma < 1$, $\phi > 1$. We think of the village fund as a relaxation of the leverage constraint ϕ.

Entrepreneur Problem II

The law of motion for wealth for entrepreneurs is

$$L^e_{it+1}(a') = \int_{a:a'=g^e(i,a)} L^e_{it}(a)da \quad \forall i$$

Since entrepreneurs cannot migrate, we do not need to consider flows of entrepreneurs between villages.

Equilibrium

A stationary equilibrium is wages $\{w(i)\}$, asset policy functions $\{g^w(i,a), g^e(i,a)\}$, and distribution of workers and entrepreneurs across villages and assets $L^w_{it}(a), L^e_{it}(a)$ such that

1. Given wages $\{w(i)\}$, workers optimize.
2. Given wages $\{w(i)\}$, entrepreneurs optimize.
3. Labor markets clear in each village.
4. The distribution of workers across villages and assets is stationary

$$L^w_{it}(a) = L^w_{it+1}(a)$$

5. The distribution of entrepreneurs across assets is stationary

$$L^e_{it}(a) = L^e_{it+1}(a)$$

Geography and Calibration

Steps in calibrating village geography:

- Villages are randomly assigned along the circumference of a circle
- Populations randomly assigned to villages (Kaboski and Townsend 2012 find village populations are independent of location)
- Migration cost κ_{ij} is a function of distance d_{ij} (which in Thai data is travel distance, and on the circle is arc length)
- CDD has migration data between every village and Bangkok. Estimate migration share to Bangkok as a function of distance to Bangkok and use this to calibrate κ_{ij}

Calibration of Other Parameters

Table: Calibration of Model Parameters

Target Moments	Parameters
Thailand Interest rate in 2002	$r = 0.051$
Thailand Loan-to-collateral ratio, 95% quantile	$\phi = 20$
Bryan and Morten (2018), Morten and Oliveira (2018), etc.	$\nu = 3$
Thailand estimates from Ji and Townsend (2018)	$\beta = 0.9$
Thailand estimates from Paweenawat and Townsend (2014)	$\gamma = 0.16$
Thailand estimates from Paweenawat and Townsend (2014)	$\alpha = 0.33$

Computation

We compute the equilibrium using the following algorithm:

(1) Guess the wage function $w(i)$ (i.e guess wage w for every village i)

(2) Solve the household and the firm problem using value function iteration

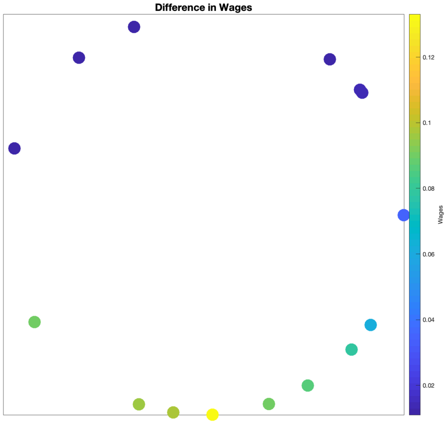
(3) Construct stationary distributions for workers and entrepreneurs

(4) Check if the labor markets clear in each village

(5) Update the wage function and repeat the previous steps until the wage function converges to a stationary equilibrium. Wage function is update by calculating a Jacobian and correcting the wages in the appropriate directions.

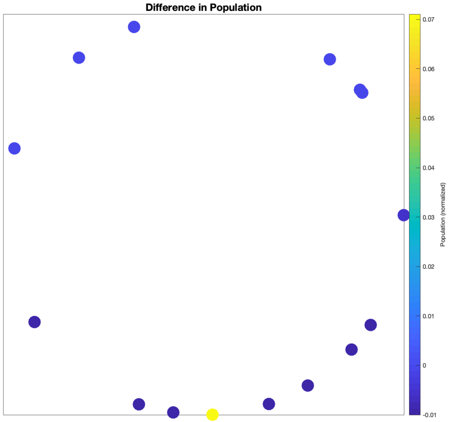
Stylized Examples of Model Mechanics: Leverage Shock

Figure: The difference in wages between two equilibria before and after leverage shock to the bottom most village.



Stylized Examples of Model Mechanics: Leverage Shock

Figure: The difference in population between two equilibria before and after leverage shock to the bottom most village.



Back to the Village Fund

How to simulate the Village Fund?

1) The Village Fund resulted in a *permanent* increase in the credit availability (Kaboski and Townsend 2011, 2012).
    - Village banks would loan out the 1 million Baht
    - Loans would be repaid
    - Banks would loan out the funds again

    In the model, we think of the village fund as permanent relaxation of the leverage constraint. We compare the equilibria before and after the shock to the leverage constraints.

2) Leverage constraint shocks are scaled inversely proportional to the village population; in the Village Fund, credit per capita increases as village size decreases.

Village Fund Simulation

We simulate the village fund program and run the following regression to compare to the data:

$$\Delta y_i = \beta \Delta \phi_i + \gamma \Delta \text{Av}\phi_{r,i} + \epsilon_i \tag{6}$$

where

- $\Delta \phi_i$ is the change in the leverage constraint scaled to inverse population size
- $\Delta \text{Av}\phi_{r,i}$ is the average change in the leverage constraint for villages within a buffer zone

Village Fund Simulation

Table: Village Fund Simulation Regressions

VARIABLES	(1) Wage	(2) Log Wage	(3) Pop	(4) Log Pop
$\Delta\phi_i$	0.00242***	0.00458***	0.000746***	0.0376***
	(0.000574)	(0.00108)	(5.87e-05)	(0.00288)
$\Delta Av\phi_{r,i}$	0.00113**	0.00214**	-8.10e-05*	-0.00430*
	(0.000434)	(0.000815)	(4.43e-05)	(0.00218)
Constant	-0.0348***	-0.0663***	-0.00707***	-0.354***
	(0.00851)	(0.0160)	(0.000870)	(0.0427)
Observations	50	50	50	50
R^2	0.310	0.312	0.794	0.803

*** p<0.01, ** p<0.05, * p<0.1

Comparison to Data

We are able to match:

- Increase in wages
- Credit spillovers in wages
- Credit spills over less onto isolated villages
- Increase in investment
- Increase in profits

We are not able to match:

- In the data, consumption initially increases and then decreases.

Macro Variables and Welfare

Workers: Increasing wages for all workers, thus increasing welfare.

Entrepreneurs:

- Direct effect: Output, consumption, capital usage, profits increase.
- Spillover effect: Entrepreneurs in highly populated villages near small villages are hurt by the increased wages.

A discussion about welfare must consider the transition paths (in progress).

Unequal effects across workers and villages: workers who can migrate right away capture more of the gains from the village fund, other workers need to save wealth in order to migrate.

Counterfactuals

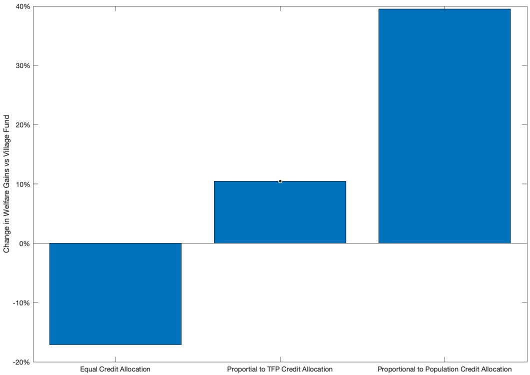
How do we allocate credit to maximize welfare?

3 possible counterfactual allocations of credit:

- Relax leverage constraints equally across all villages
- Relax leverage constraints proportional to TFP
- Relax leverage constraints proportional to village population

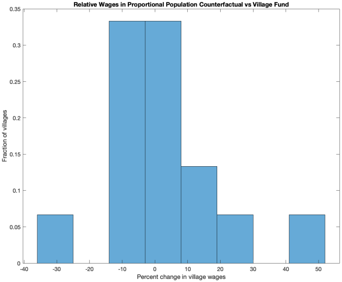
Counterfactuals: Welfare

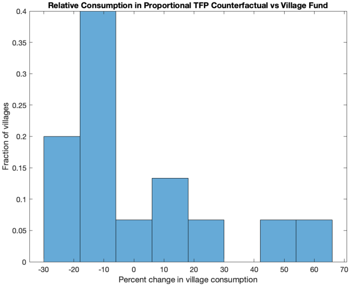
Figure: Relative welfare gains of counterfactuals to Village Fund



Counterfactuals: Wages and Consumption

Figure: Left: Relative Wages in counterfactual where leverage constraints are relaxed proportional to village population vs Village Fund. Right: Relative Consumption in counterfactual where leverage constraints are relaxed proportional to village TFP vs Village Fund.





Concluding Thoughts

Why do you need a model with multiple villages to think about scaling-up?

1) Macro Aggregates differ from one village model and a general equilibrium model with price effects but without spatial frictions
2) Village heterogeneity and spatial linkages result in spatially unequal effects of the policy on firms and workers