

**14.772**  
**Spring, 2020**

**Multiple Obstacles in Economy-Wide  
Models: Realistic vs. Ad Hoc**

**(Lecture 8)**

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## **Lecture 8: Multiple Obstacles in Economy-Wide Models: Realistic vs Ad Hoc, with Policy Implications (4/2)**

\*Moll, Benjamin, Robert M. Townsend, and Victor Zhorin. "Economic development, flow of funds, and the equilibrium interaction of financial frictions." *Proceedings of the National Academy of Sciences* 114.24 (2017): 6176-6184.

\*Era Dabla-Norris & Yan Ji & Robert M. Townsend & D. Filiz Unsal, 2015. "Distinguishing Constraints on Financial Inclusion and Their Impact on GDP, TFP, and Inequality," NBER Working Papers 20821, National Bureau of Economic Research, Inc.

Flow of Funds Within and Across Countries

Cole, H. L., Greenwood, J. and Sanchez, J. M. (2016), Why Doesn't Technology Flow From Rich to Poor Countries? *Econometrica*, 84: 1477-1521. doi:10.3982/ECTA11150

# **Economic Development, Flow of Funds, and the Equilibrium Interaction of Financial Frictions**

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# MICRO FOUNDATIONS, VARYING OBSTACLES, USING TOWNSEND THAI DATA

Limited Commitment in the Northeast/rural vs Moral Hazard in Central/Urban

From three separate studies:

**Paulson, Townsend and Karaivanov (2006), Paulson and Townsend (2004):**

Enterprise and Financing

Data, 1997 baseline and retrospective, 2880 households

Location

Lopburi, Chacherngsao: central, industrialized and/or cash crops  
Srisaket, Buriram: northeast, poor, agrarian

Comparison of obstacles

Moral Hazard, Aghion and Bolton (1997), Piketty (1997), vs  
Limited commitment, Evans and Jovanovic (1989)  
not all theories previously taken to data and compared  
Stratified Random Sample of Tambon, Villages, Households  
prior wealth and going into business  
shops, restaurants, commercial shrimp, dairy cattle

Tests:

mechanism design to get likelihood, quantitative mapping (with specification of talent)  
wealth and borrowing positive correlated in NE, negatively correlated in Central

**Ahlin and Townsend (2007)**

Repayment data/Default

1997 baseline using 226 joint liability groups pf BAAC,  
experience repayment difficulties

comparing theories (not previously tested): Besley and Coate (1995) (repayment s/o commitment),  
Banerjee, Besley and Guinnane (1994) (monitoring of the borrower), Stiglitz (1990) (joint project choice in  
production), Ghatak, Morelli and Sjostrom (2001) (adverse selection)

Findings: Limited Enforcement in the NE: village penalties positively correlated with repayments; Adverse  
Selection in Central: degree of joint liability negatively correlated with repayment

# MICRO FOUNDATIONS, VARYING OBSTACLES, USING TOWNSEND THAI DATA (cont.)

## **Karaivanov and Townsend (2014): Dynamics of Multiple Variables**

Dynamic model

Comparing likelihoods, Vuong tests for non-nested regimes

Autarky, savings only, borrowing/lending, moral hazard with observed, unobserved capital

Cross section and panel data:  $c, q, \{k, l, q\}, \{c, k, l, q\}$

Findings

Moral Hazard, urban

Savings only in rural

Consumption data is smoothed in both but in rural persistence of capital stocks is decisive

# Common Theoretical Framework

- Continuum of households and continuum of intermediaries
- HHs have preferences over consumption and effort:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, e_t).$$

- Occupational choice: entrepreneur ( $x = 1$ ) or worker ( $x = 0$ ).

## Entrepreneurs and Workers

- **Entrepreneurs,  $x = 1$ :** technologies

$$z\varepsilon f(k, \ell)$$

- $z$ : entrepreneurial ability, Markov process  $\mu(z'|z)$ .
  - $\varepsilon$ : residual productivity, with distribution  $p(\varepsilon|e)$ .
  - $\varepsilon$  potentially insurable,  $z$  **not** insurable
- **Workers,  $x = 0$ :** supply  $\varepsilon$  efficiency units of labor, with distribution  $p(\varepsilon|e)$ .
- Note:
    - if  $x = 1$ ,  $\varepsilon =$  firm residual productivity
    - if  $x = 0$ ,  $\varepsilon =$  worker productivity
    - can allow for differential responsiveness to  $e$  by rescaling

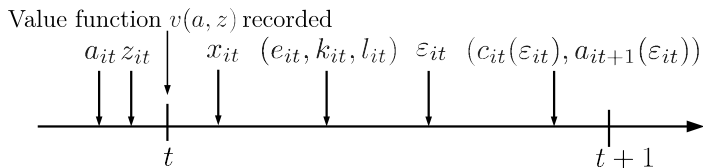
# Risk-Sharing with Intermediaries

- Continuum of risk-neutral intermediaries, outside financial institutions
- Continuum of risk-averse households
  - initial wealth  $a_{i0}$  and income stream  $\{y_{it}\}_{t=0}^{\infty}$ .
  - can access capital market only via intermediaries
  - as if aggregating up households within villages to Gorman representative
- Each intermediary contracts with continuum of households to form “risk-sharing syndicate”
  - HHs give entire initial wealth and income stream to intermediaries
  - as if syndicate is contracting with capital goods sector
  - We emphasize a borrowing, lending interpretation
  - intermed. pool these, invest at  $r$ , transfer consumption to HHs
  - Again: only residual productivity,  $\varepsilon$ , insurable but not ability,  $z$
- “Risk-sharing syndicates” take  $(w, r)$  as given



# Optimal Contract and Timing

- Optimal contract:
  - ① leaves zero profits to intermediary  $\Leftrightarrow$  maximizes individual's utility
  - ② assigns occupation,  $x$ , effort,  $e$ , capital,  $k$ , and labor,  $\ell$ . After  $\varepsilon$  is drawn, assigns consumption and savings  $c(\varepsilon)$  and  $a'(\varepsilon)$



## Optimal Contract: Bellman Equation

$$v(a, z) = \max_{e, x, k, \ell, c(\varepsilon), a'(\varepsilon)} \sum_{\varepsilon} p(\varepsilon|e) \{u[c(\varepsilon), e] + \beta \mathbb{E}_{z'} v[a'(\varepsilon), z']\} \quad \text{s.t.}$$

$$\begin{aligned} & \sum_{\varepsilon} p(\varepsilon|e) \{c(\varepsilon) + a'(\varepsilon)\} \\ & \leq \sum_{\varepsilon} p(\varepsilon|e) \{x[z\varepsilon f(k, \ell) - w\ell - (r + \delta)k] + (1 - x)w\varepsilon\} + (1 + r)a \end{aligned}$$

and s.t. regime-specific constraints: moral hazard or limited commitment depending on sector

Equivalent problem when  $z$  is contractable or fixed at  $z = 1$ : maximize present discounted value of profits subject to promised utility, very slow moving dynamics

## Moral Hazard, Urban/Central, $m$

- effort,  $e$ , unobserved  $\Rightarrow$  moral hazard problem.
- Note: moral hazard for **both** entrepreneurs and workers.
- IC constraint:

$$\sum_{\varepsilon} p(\varepsilon|e) \{u[c(\varepsilon), e] + \beta \mathbb{E}_{z'} v[a'(\varepsilon), z']\} \\ \geq \sum_{\varepsilon} p(\varepsilon|\hat{e}) \{u[c(\varepsilon), \hat{e}] + \beta \mathbb{E}_{z'} v[a'(\varepsilon), z']\} \quad \forall e, \hat{e}$$

- Formulation of MH problem is **special**
  - only  $e$  unobserved.  $k$  observed, no effect on shirking
  - more general formulation:  $p(\varepsilon|e, k)$

## Limited Commitment, Rural/Northeast, $1 - m$

- effort,  $e$ , observed  $\Rightarrow$  perfect insurance against production risk,  $\varepsilon$
- But collateral constraint:

$$k \leq \lambda a, \quad \lambda \geq 1$$

## Factor Demands and Steady State Equilibrium

- Denote optimal occupational choice and factor demands by

$$x(a, z), \quad \ell(a, z; w, r), \quad k(a, z; w, r)$$

- and individual (average) labor supply:

$$n(a, z; w, r) \equiv [1 - x(a, z)] \sum_{\varepsilon} p[\varepsilon | e(a, z)] \varepsilon$$

- Prices  $r$  and  $w$ , and corresponding quantities such that:

- (i) Given  $r$  and  $w$ , quantities determined by optimal contract
- (ii) Markets clear

$$\int \ell(a, z; w, r) dG(a, z) = \int n(a, z; w, r) dG(a, z)$$

$$\int k(a, z; w, r) dG(a, z) = \int a dG(a, z)$$

## Parameterization

- Preferences

$$u(c, e) = U(c) - V(e), \quad U(c) = \frac{c^{1-\sigma}}{1-\sigma}, \quad V(e) = \frac{\chi}{1+1/\varphi} e^{1+1/\varphi}$$

- Production function:  $\varepsilon z f(k, \ell) = \varepsilon z k^\alpha \ell^\gamma$ ,  $\alpha + \gamma < 1$
- Ability process: keep current  $z$  with prob.  $\rho$ , draw new one with prob.  $1 - \rho$  from truncated Pareto:

$$\Psi(z) = \frac{1 - (z/\bar{z})^{-\zeta}}{1 - (\bar{z}/\underline{z})^{-\zeta}}$$

- Residual productivity  $\varepsilon \in \{\varepsilon^L, \varepsilon^H\}$

$$p(\varepsilon^H | e) = (1 - \theta) \frac{1}{2} + \theta \frac{e - \underline{e}}{\bar{e} - \underline{e}}, \quad \theta \in (0, 1)$$

- Next slide: parameter values
- Paper: huge number of robustness checks

Variable	grid size	grid range
Wealth, $a$	30	[0, 200]
Ability, $z$	15	[1, 4]
Consumption, $c$	30	[0.00001, $\bar{c}(w, r)$ ]
Efficiency, $\varepsilon$	2	[0, 2]
Effort, $e$	2	[0.1, 1]

## Parameter Values (Thailand and other studies)

Parameter	Value	Description
$\beta$	$1.05^{-1}$	discount factor
$\sigma$	2	inverse of intertemporal elasticity of substitution: KT, PTK
$\varphi$	2	Frisch elasticity: KT, PTK, BCTY
$\chi$	0.525	disutility of labor: KT, PTK
$\alpha$	0.3	exponent on capital in production function: $P_1 T$ , BBT
$\gamma$	0.4	exponent on labor in production function: $P_1 T$
$\delta$	0.06	depreciation rate: ST
$\rho$	0.75	persistence of entrepreneurial talent: $P_2 T$
$\zeta$	1	tail param. of talent distribution (truncated Pareto)
$\underline{z}$	1	lower bound on entrepreneurial talent
$\bar{z}$	4	upper bound on entrepreneurial talent
$\theta$	0.2	sensitivity of residual productivity to effort
$\varepsilon^L$	0	value of low residual productivity draw
$\varepsilon^H$	2	value of high residual productivity draw
$\lambda$	1.8	tightness of collateral constraints: PTK
$m$	0.3	population weight: census - 0.31; Lucas Jr (2004) - 0.22 (from World Bank)

PTK - Paulson, Townsend and Karaivanov (2006), KT -Karaivanov and Townsend (2014),  $P_1 T$  - Paweenawat and Townsend (2012),  $P_2 T$ -Pawasutipaisit and Townsend (2011), ST - Samphantharak and Townsend (2010), BBT - Banerjee, Breza, and Townsend, BCTY - Bonhomme, Chiappori, Townsend, and Yamada

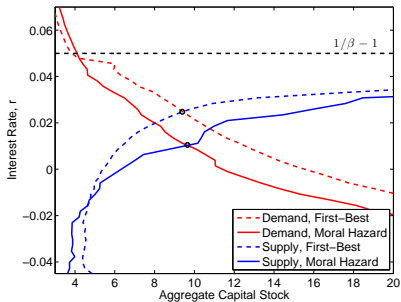
## LC and MH Sectors in Mixed Regime

	Mixed Regime, $m=0.3$	MH sector	LC sector
	(a) National and Sectoral Aggregates		
TFP (% of FB)	0.964	0.974	1.015
GDP (% of FB)	0.859	1.258	0.688
Consumption (% of FB)	0.410	0.859	0.217
Welfare (% of FB)	0.806	0.898	0.766
Wealth (% of FB)	0.914	1.082	0.842
Credit (% of FB)	0.769	1.944	0.265
Wage (% of FB)	0.876	0.876	0.876
Interest Rate	-0.003	-0.003	-0.003
% Entrepreneurs	0.189	0.190	0.188
	(b) Importance of Sectors in Aggregate Economy		
% Sector Contributes to GDP		0.439	0.561
% of Labor Employed in Sector		0.440	0.560
% of Capital Used in Sector		0.621	0.379
% of Labor Supplied by Sector		0.274	0.726
% of Capital Supplied by Sector		0.355	0.645
	(c) Intersectoral Capital and Labor Flows		
Net Labor Inflow (% of used)		0.381	-0.288
Net Capital Inflow (% of used)		0.418	-0.735

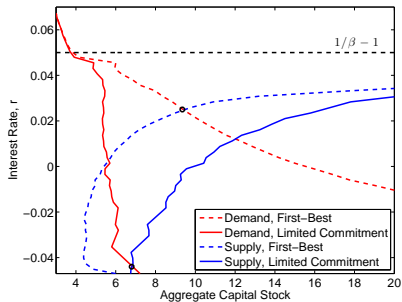
# Determination of Equilibrium $r$

## Limited Commitment and Moral Hazard

### Moral Hazard



### Limited Commitment



Note: wage is lower in LC regime too



# Determination of Equilibrium $r$

## Limited Commitment

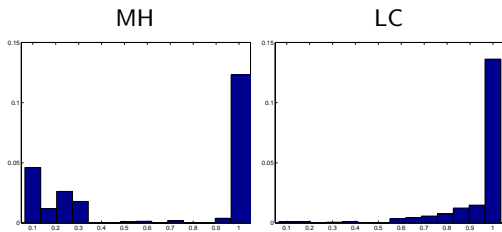
- Capital **demand** shifts **left**
  - reason: collateral constraint  $\Rightarrow$  capital demand constrained
- Capital **supply** shifts **right**
  - reason: self-financing of entrepreneurs (Buera, Kaboski and Shin, 2011; Buera and Shin, 2013, among others)

## Moral Hazard

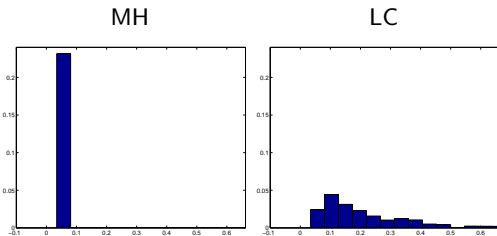
- Capital **demand** shifts **left**
  - reason: suboptimal effort  $\Rightarrow$  depressed capital productivity
- Capital **supply**: effect **ambiguous**
  - reason: two **countervailing** effects
  - ① **direct effect**: at constant  $w$ , capital supply  $\downarrow$  **always**.  
Inverse Euler equation logic: optimal contract discourages savings whenever IC constraint binds
  - ② **GE effect** decrease in capital  $\downarrow \Rightarrow$  decrease in labor demand  $\downarrow \Rightarrow$  lower wage  $\downarrow \Rightarrow$  more firms  $\uparrow$

# Mixed MH+LC Regime

## Distribution of Entrepreneurial Effort

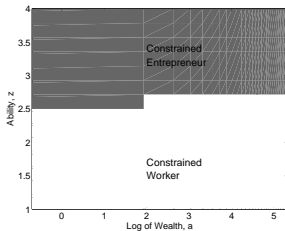


## Distribution of MPKs

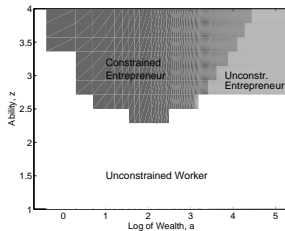


# Occupational Choice/Saving-Borrowing in Mixed MH+LC Regime

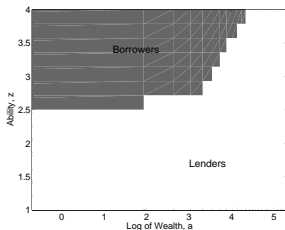
## Moral Hazard



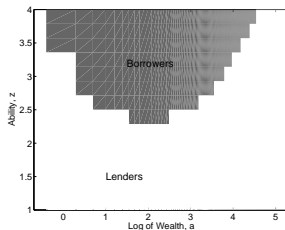
## Limited Commitment



## Moral Hazard

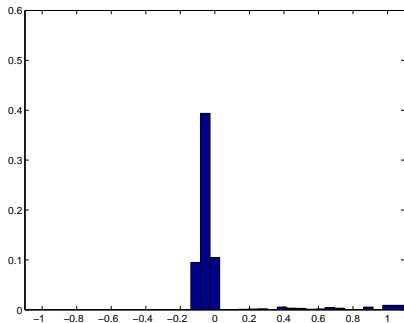


## Limited Commitment

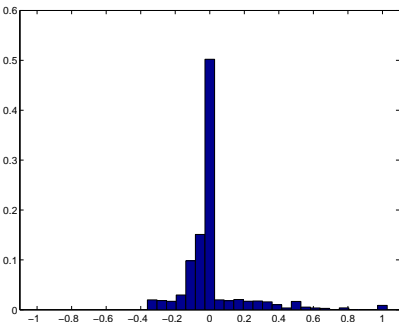


# Underlying Micro Dynamics of Wealth Growth Rates in Mixed MH+LC Regime

## Moral Hazard



## Limited Commitment

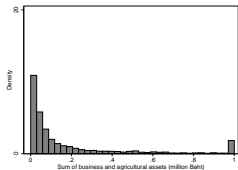


## Another Experiment: LC Sectors in Mixed LC+LC Regime

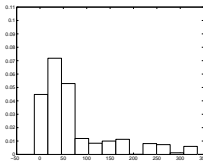
	Mixed Regime, $m=0.3$	LC, $\lambda=3$ (Urban)	LC, $\lambda=1.8$ (Rural)
(a) National and Sectoral Aggregates			
GDP (% of FB)	0.827	1.398	0.583
TFP (% of FB)	0.894	0.827	0.985
Capital-Output Ratio (%of FB)	0.993	1.189	0.792
Labor Supply (% of FB)	1.012	1.711	0.713
Welfare (% of FB)	0.641	0.688	0.621
Wage (%of FB)	0.817	0.817	0.817
Interest Rate	-0.024	-0.024	-0.024
% Entrepreneurs	0.199	0.287	0.161
External Finance/Sectoral GDP	1.233	1.246	1.219
(b) Importance of Sectors in Aggregate Economy			
% Sector Contributes to GDP		0.507	0.493
% of Labor Employed in Sector		0.507	0.493
% of Capital Used in Sector		0.607	0.393
% of Labor Supplied by Sector		0.257	0.743
% of Capital Supplied by Sector		0.502	0.498
(c) Intersectoral Capital and Labor Flows			
Net Labor Inflow (% of used)		0.487	-0.527
Net Capital Inflow (% of used)		0.176	-0.261

# Out of Sample Predictions Firm Size Distributions

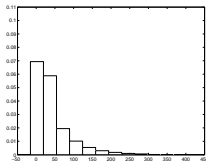
Data:Urban



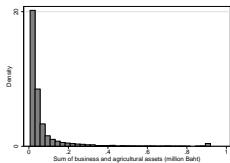
Model:MH(+LC)



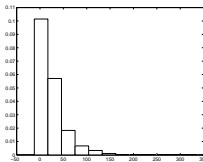
Model:LC, $\lambda = 3$



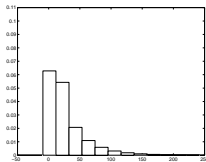
Data:Rural



Model:LC(+MH)



Model:LC, $\lambda = 1.8$



## Conclusion

- Different financial frictions not only have **different macroeconomic effects** but also **interact** in unexpected ways
- **Needed:** more research that makes use of **micro data** and takes seriously the micro financial underpinnings of **macro models**.
- **Big Data with Big Theory**
- Join what have been largely two distinct literatures – macro development and micro development – into a coherent whole:
  - macro development needs to take into account the contracts we see on the ground
  - micro development needs to take into account GE effects of interventions

# Distinguishing Constraints on Financial Inclusion and Their Impact on GDP, TFP, and the Distribution of Income

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February 13, 2020

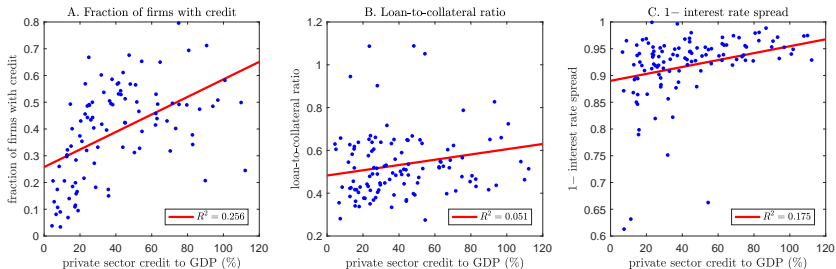


# Motivation

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- ▶ The development of a financial system is multi-faceted in nature.
- ▶ The extent of financial inclusion is mainly reflected by
  - ▶ **Breadth** – ability of firms to access credit
  - ▶ **Depth** – the amount of collateral required for borrowing
  - ▶ **Efficiency** – ability of financial intermediaries to provide services at low cost.
- ▶ These three characteristics can be measured (proxied) in the data:
  - ▶ **Fraction of firms with credit** → breadth
  - ▶ **Loan-to-collateral ratio** → depth
  - ▶ **One minus the interest rate spread** → efficiency

# Large heterogeneity exists across different countries



- ▶ More developed financial systems are usually associated with greater breadth, depth, and efficiency. But there exists significant cross-country difference.
- ▶ Correlation among the three measures is not high.
  - ▶  $\text{Corr}(\text{breadth, depth})=0.11$ ;  $(\text{depth, efficiency})=0.09$ ;  $(\text{efficiency, breadth})=0.37$

# Research questions and approach

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- ▶ **How different constraints interact in equilibrium?**
- ▶ **Which constraint is most binding? which policy is most effective?**
- ▶ **Are there tradeoffs that policy makers should be aware of?**
  
- ▶ We take a structural approach to address these questions.
  - ▶ Reduced-form regressions do not offer revealing answers because different constraints have nonlinear interactions and policies bring GE effects.
  - ▶ Calibrate the model to match the three measures of financial characteristics.
  - ▶ Let the model speak through various counterfactual experiments.
  
- ▶ Instead of deriving optimal policies based on specific objectives and cost functions, we highlight, distinguish, and systematically examine the tradeoffs between various policy instruments as an essential first step in policy design.

# Overview of the results

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- ▶ A GE model of heterogeneous agents with three sources of financial frictions:
  - ▶ Agents who borrow incur a fixed credit entry cost.
  - ▶ Borrowing is subject to a collateral constraints.
  - ▶ Loan rate is higher than deposit rate.

## Main implications:

- ▶ Policies should target most binding constraint, which varies across countries.
- ▶ There are tradeoffs between financial inclusion, GDP, and income distribution.
  - ▶ Policies that increase GDP may lead to high income inequality.
  - ▶ Short-run transitional effects may differ from outcomes in long-run steady states.
    - ▶ e.g., policies that increase GDP may lead to high income inequality and the extent of these tradeoffs can vary over time after implementation.
- ▶ We provide a roadmap for policy makers so that they know what they are likely to face in the future.

# Related literature

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- ▶ Most existing models emphasize one particular type of financial frictions
  - ▶ Credit entry cost: e.g. Greenwood, Jovanovic (1990); Townsend, Ueda (2006)
  - ▶ Collateral constraint: e.g. Jermann, Quadrini (2009); Buera and Shin (2013)
  - ▶ Intermediation cost: e.g. Greenwood, Sanchez and Wang (2010, 2013)
  
- ▶ Studies that model and compare multiple frictions:
  - ▶ Moral hazard vs limited commitment: Albuquerque, Hopenhayn (2004); Clementi, Hopenhayn (2006); Ahlin, Townsend (2007); Moll, Townsend, Zhorin (2014)
  - ▶ Moral hazard with/without hidden savings vs full information: Abraham, Pavoni (2005); Doepke, Townsend (2006)
  - ▶ Adverse selection vs limited commitment: Martin and Taddei (2013)
  - ▶ Moral hazard vs limited savings: Paulson, Townsend, Karaivanov (2006), Karaivanov, Townsend (2014)
  - ▶ Moral hazard vs limited commitment vs hidden income: Kinnan (2014)
  - ▶ A structural corporate model with multiple financial frictions: Nikolov, Schmid, Steri (2020)

# Agents

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- ▶ Discrete time indexed by  $t$ .
- ▶ A continuum of agents heterogeneous in wealth  $b_t$  and productivity  $z_t$
- ▶ Productivity  $z_t$  evolves according to an exogenous stochastic process:
  - ▶ With prob.  $\gamma$ ,  $z_t = z_{t-1}$ ; with prob.  $1 - \gamma$ , draw a new  $z_t$  from  $\mu(z)$ .
  - ▶  $\mu(z)$  is a Pareto distribution with tail parameter  $\theta$ .
- ▶ Agents derive utility from consumption  $c_t$ :

$$\mathbb{E}_t \left[ \sum_{s=t}^{\infty} \beta^{s-t} \frac{c_s^{1-\sigma}}{1-\sigma} \right],$$

where the discount factor is  $\beta$ , and the risk-aversion is  $\sigma$ .

# Technology

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- ▶ Agents can choose to be workers or entrepreneurs.
- ▶ Workers supply labor and earn wage  $w_t$ .
- ▶ Entrepreneurs use capital  $k_t$  and labor  $l_t$  to produce output.

$$f(k_t, l_t, z_t) = z_t(k_t^\alpha l_t^{1-\alpha})^{1-\nu},$$

where  $\nu$  is the span-of-control, and  $\alpha$  is the capital share.

- ▶ Capital  $k_t$  depreciates at rate  $\delta$ .

# Financial market

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Three sources of financial frictions:

- ▶ Limited credit access: entrepreneurs incur a fixed cost  $\psi$  to borrow.
  - ▶  $\psi$  captures various fees associated with financial accounts, the cost of bookkeeping and exchange (transportation), and others.
  - ▶ Agents are in the “credit regime” after paying  $\psi$ , otherwise, in “savings regime”
- ▶ Collateral constraint:  $k_t \leq (b_t - \psi)/\xi$ .
  - ▶  $\xi$  captures the tightness of borrowing constraint.  $\xi = 1$  means financial autarky.
- ▶ Intermediation inefficiency: lending rate  $r_t^l = r_t + \chi$ , where  $r_t$  is deposit rate.
  - ▶  $\chi$  may capture, e.g., the cost of enforcement and monitoring.

Financial inclusion means reducing the values of  $\psi$ ,  $\xi$ , and  $\chi$ .



# Agents' problem

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- ▶ Agents make occupation choice to maximize utility

$$V_t(b_t, z_t) = \max \left\{ \underbrace{W_t(b_t, z_t)}_{\text{worker}}, \underbrace{E_t(b_t, z_t)}_{\text{entrepreneur}} \right\}$$

- ▶ Workers' problem is

$$W_t(b_t, z_t) = \max_{c_t} \frac{c_t^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}_t [V_{t+1}(b_{t+1}, z_{t+1})]$$

s.t.  $c_t + b_{t+1} = (1 + r_t)b_t + w_t$ , with  $c_t, b_{t+1} \geq 0$ .

- ▶ Entrepreneurs decide whether to borrow from financial intermediaries:

$$E_t(b_t, z_t) = \max \left\{ \underbrace{E_t^s(b_t, z_t)}_{\text{savings regime}}, \underbrace{E_t^c(b_t, z_t)}_{\text{credit regime}} \right\}.$$

# Entrepreneurs' problem

---

- ▶ In the savings regime, the entrepreneur finances production herself.

$$E_t^s(b_t, z_t) = \max_{c_t, k_t, l_t} \frac{c_t^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}_t [V_{t+1}(b_{t+1}, z_{t+1})]$$

s.t.  $c_t + b_{t+1} = z_t(k_t^\alpha l_t^{1-\alpha})^{1-\nu} + (1-\delta)k_t - w_t l_t + (1+r_t)(b_t - k_t),$   
 $k_t \leq b_t$  and  $c_t, k_t, l_t, b_{t+1} \geq 0.$

- ▶ In the credit regime, the entrepreneur takes out loans to finance production.

$$E_t^c(b_t, z_t) = \max_{c_t, k_t, l_t} \frac{c_t^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}_t [V_{t+1}(b_{t+1}, z_{t+1})]$$

s.t.  $c_t + b_{t+1} = z_t(k_t^\alpha l_t^{1-\alpha})^{1-\nu} + (1-\delta)k_t - w_t l_t - (1+r_t+\chi)(k_t - b_t + \psi),$   
 $\xi k_t \leq b_t - \psi$  and  $c_t, l_t, b_{t+1} \geq 0$  and  $k_t > b_t.$

# Competitive Equilibrium

---

- Denote by  $h_t(b, z)$  the joint distribution of wealth and productivity at  $t$ .

Given an initial distribution  $h_0(b, z)$ , a competitive equilibrium consists of allocations  $\{c_t(b, z), k_t(b, z), l_t(b, z)\}_{t=0}^{\infty}$ , sequences of joint distributions of wealth and productivity  $\{h_t(b, z)\}_{t=0}^{\infty}$  and prices  $\{r_t, w_t\}_{t=0}^{\infty}$  such that:

- (1) Agents optimally choose the underlying regime, occupation, consumption  $c_t(b, z)$ , capital  $k_t(b, z)$ , and labor  $l_t(b, z)$  to maximize utility at all  $t \geq 0$ .
- (2) The capital market clears at all  $t \geq 0$ ,

$$\begin{aligned} & \iint_{(b,z) \in \Phi_t^C} [k_t(b, z) - b + \psi] h_t(b, z) db dz \\ &= \iint_{(b,z) \notin \Phi_t^E} b h_t(b, z) db dz + \iint_{(b,z) \in \Phi_t^S} [b - k_t(b, z)] h_t(b, z) db dz, \end{aligned}$$

where  $\Phi_t^E$  is the set of entrepreneurs at time  $t$ ;  $\Phi_t^S$  and  $\Phi_t^C$  are the sets of entrepreneurs in the savings and credit regimes, respectively.

## Competitive Equilibrium (continued)

---

(3) The labor market clears at all  $t \geq 0$ ,

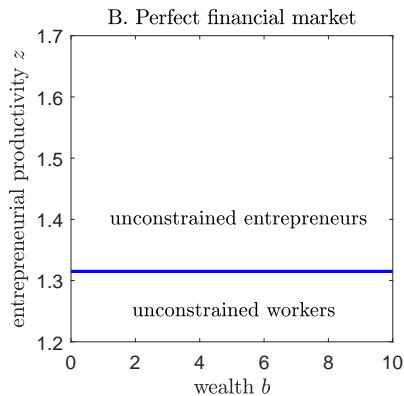
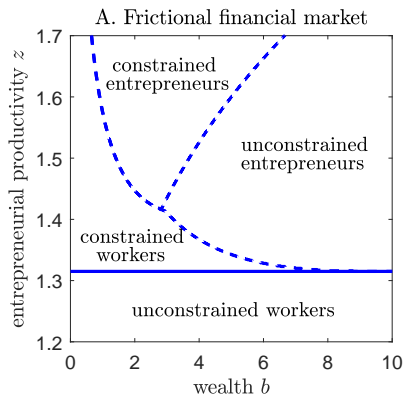
$$\iint_{(b,z) \in \Phi_t^E} l_t(b,z) h_t(b,z) db dz = \iint_{(b,z) \notin \Phi_t^E} h_t(b,z) db dz.$$

(4)  $\{h_t(b,z)\}_{t=0}^\infty$  evolves according to the equilibrium mapping

$$\begin{aligned} h_{t+1}(b', z') db dz = & \gamma dz \int \mathbb{1}_{\{b^*=b'\}} h_t(b, z') db \\ & + (1 - \gamma) \mu(z') dz \iint \mathbb{1}_{\{b^*=b'\}} h_t(b, z) db dz, \end{aligned}$$

where  $b^* \equiv b_{t+1}(b, z)$  is the wealth at  $t + 1$  implied by the optimal savings decision of agents of type  $(b, z)$ .  $\mathbb{1}_{\{b^*=b'\}}$  is an indicator function which equals one if  $b^* = b'$  and zero otherwise. The left-hand side of the equation is the probability mass of agents with  $(b', z')$  at  $t + 1$ . The right-hand side sums the probabilities of transition to  $(b', z')$  from any arbitrary  $(b, z)$  at  $t$ . With probability  $\gamma$ , the agent keeps the current productivity  $z'$  and transits to  $b'$  from  $(b, z')$  if  $b^* = b'$ . With probability  $1 - \gamma$ , the agent draws a new productivity, which equals  $z'$  with probability  $\mu(z') dz$ .

# Occupation choice with/without financial frictions



# Data and calibration

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- ▶ Firm-level data from world bank enterprise surveys.
- ▶ Take the Philippines as the benchmark calibration.
  - ▶ 1,335 firms interviewed from Nov. 2014 through May 2016

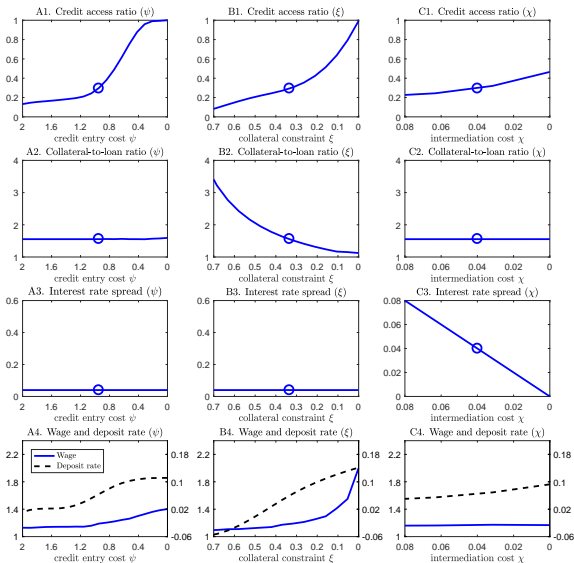
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	Data	Model	Parameter
Firms with credit (%)	29.9	29.5	$\psi = 0.95$
Collateral (% of loans)	156.7	156.4	$\xi = 0.335$
Interest rate spread (%)	4.0	4.0	$\chi = 0.04$
Real interest rate (%)	6.2	6.3	$\beta = 0.88$
Employment share of top 5% (%)	43.7	43.7	$\theta = 3.4$
Employment share of top 10% (%)	57.6	58.6	$\gamma = 0.89$
Employment share of top 20% (%)	73.2	71.5	
Employment share of top 40% (%)	88.8	85.3	
Gross savings (% of GDP)	44.2	41.2	

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# Identification of financial-friction parameters



Note: The blue circle in each panel represents the corresponding value under our calibration.

# Financial inclusion policy instruments

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We study the following three policy instruments:

- ▶ Reducing the credit entry cost  $\psi$ .
  - ▶ e.g., promote branch opening in rural locations with unbanked populations.
- ▶ Relaxing the collateral constraint  $\xi$ .
  - ▶ e.g., during the 2007-2008 financial crisis, many countries widened the range of securities that could be accepted as collateral.
- ▶ Reducing the intermediation cost  $\chi$ .
  - ▶ e.g., policies that increase competition among financial institutions can accelerate investment in fintech and improve intermediation efficiency.

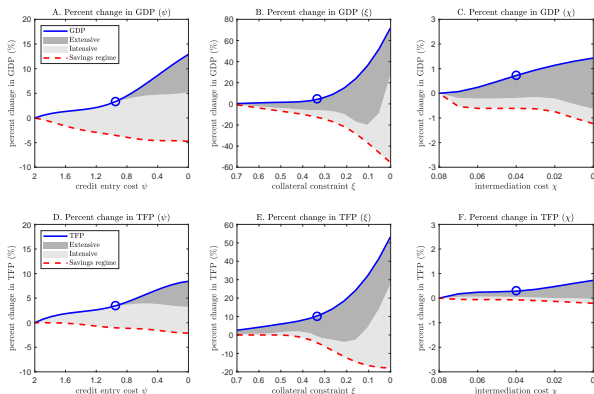
Financial inclusion leads to changes in GDP and TFP through three margins

- ▶ Extensive margin: entrepreneurs move from savings regime to credit regime.
- ▶ Intensive margin: entrepreneurs in the savings regime scale up their production.
- ▶ Savings regime: GE effects due to changes in interest rates and wages.

The model structure provides these decompositions with formulas, which are also quantified in the data, as are the GE effects on wages and interest rates.



# Impact of financial inclusion on GDP and TFP



- ▶ Relaxing the collateral constraint has a larger impact on increasing GDP and TFP than reducing the credit entry cost or the intermediation cost.
- ▶ The increase in GDP and TFP is attributed to different margins depending on which policy instrument is used (see next slide).

# Policies instruments work through different margins

---

The increase in GDP and TFP is attributed to different margins depending on which policy instrument is used, for example:

- ▶ When the credit entry cost is reduced, GDP and TFP will initially increase mostly through the intensive margin
  - ▶ The few entrepreneurs who already have access to finance will expand their scale of production
  - ▶ Intuition: most entrepreneurs do not have sufficient wealth to pay the upfront cost and are excluded from the credit market
- ▶ When the credit entry cost is further lowered, however, GDP and TFP will increase through the extensive margin
  - ▶ Productive but wealth-constrained entrepreneurs who were previously excluded from the credit market will start to gain access to finance.
- ▶ When the collateral constraint is relaxed, both intensive and extensive margins will contribute significantly to the increase in GDP and TFP.
- ▶ When the intermediation cost is lowered, the increase in GDP and TFP is attributed only to the extensive margin.

# Interactions through the extensive margin

---

## Proposition 1

Let  $\underline{b}(\Omega) \equiv \underline{b}(z; \Omega)$  be the threshold of wealth above which entrepreneurs of productivity  $z$  choose to access credit in the economy with  $\Omega$ . Consider fixed interest rate  $r$ , wage  $w$ , and  $\nu = 0$ . We have

- ▶ Tightening each financial constraint reduces credit access:

$$\frac{\partial \underline{b}(\Omega)}{\partial \psi}, \quad \frac{\partial \underline{b}(\Omega)}{\partial \xi}, \quad \frac{\partial \underline{b}(\Omega)}{\partial \chi} \geq 0.$$

- ▶  $\underline{b}(\Omega)$  has submodularity in  $\Omega$ , suggesting that the effect through the extensive margin of tightening one constraint is larger when the other constraints are more tightened:

$$\frac{\partial^2 \underline{b}(\Omega)}{\partial \psi \partial \xi} = \frac{\partial^2 \underline{b}(\Omega)}{\partial \xi \partial \psi}, \quad \frac{\partial^2 \underline{b}(\Omega)}{\partial \xi \partial \chi} = \frac{\partial^2 \underline{b}(\Omega)}{\partial \chi \partial \xi}, \quad \frac{\partial^2 \underline{b}(\Omega)}{\partial \chi \partial \psi} = \frac{\partial^2 \underline{b}(\Omega)}{\partial \psi \partial \chi} \geq 0.$$

# Interactions through the intensive margin

---

## Proposition 2

Let  $y^C(\Omega) \equiv y^C(b, z; \Omega)$  be the net output of entrepreneurs of productivity  $z$  and wealth  $b$  in the credit regime. Consider fixed interest rate  $r$ , wage  $w$ , and  $\nu = 0$ . We have

- ▶ Tightening each financial constraint reduces output:

$$\frac{\partial y^C(\Omega)}{\partial \psi}, \quad \frac{\partial y^C(\Omega)}{\partial \xi}, \quad \frac{\partial y^C(\Omega)}{\partial \chi} \leq 0.$$

- ▶  $y^C(\Omega)$  has supermodularity, suggesting that the effect through the intensive margin of tightening one constraint is smaller when the other constraints are more tightened:

$$\frac{\partial^2 y^C(\Omega)}{\partial \psi \partial \xi} = \frac{\partial^2 y^C(\Omega)}{\partial \xi \partial \psi}, \quad \frac{\partial^2 y^C(\Omega)}{\partial \xi \partial \chi} = \frac{\partial^2 y^C(\Omega)}{\partial \chi \partial \xi}, \quad \frac{\partial^2 y^C(\Omega)}{\partial \chi \partial \psi} = \frac{\partial^2 y^C(\Omega)}{\partial \psi \partial \chi} \geq 0.$$

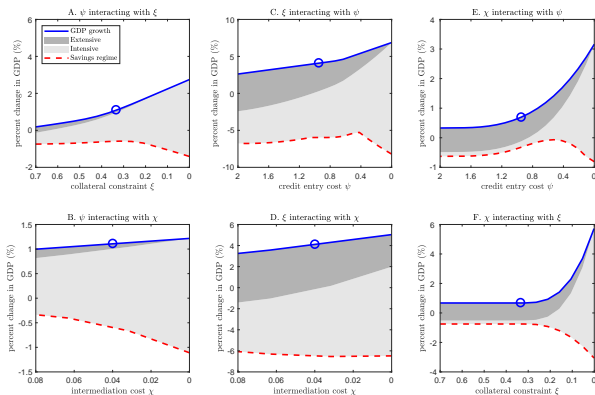
# Implications of the interaction effect

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- ▶ Different constraints are complements through the intensive margin and substitutes through the extensive margin.
- ▶ If the interaction effect through the intensive margin dominates,
  - ▶ relaxing multiple constraints simultaneously brings larger GDP gains than relaxing each constraint separately.
  - ▶ Thus, policy makers should develop a more balanced financial system by alleviating the currently most binding constraint.
    - ▶ Note that the currently most binding constraint may change over time after implementing policies.
- ▶ If the interaction effect through the extensive margin dominates,
  - ▶ relaxing multiple constraints simultaneously brings smaller GDP gains than relaxing each constraint separately.
  - ▶ Thus, policy makers should alleviate a single constraint while ignoring all other constraints.

# Quantitative evaluation of the interaction effect

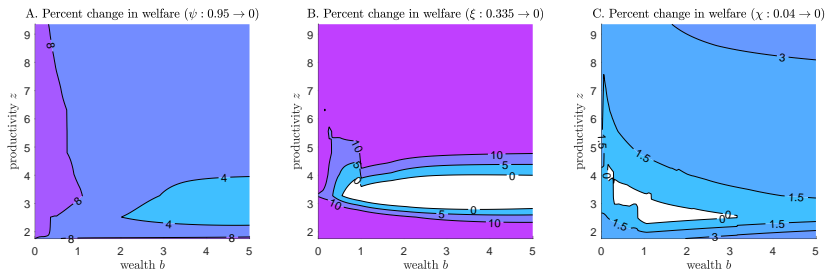
- ▶ The net effect on GDP is larger when policy makers alleviate multiple financial constraints together than when they relax the financial constraints individually.



Note: Panels A and B present the percentage increase in steady-state GDP when  $\psi$  is reduced from its calibrated value of 0.95 to 0.8. Panel A shows the impact of reducing  $\psi$  for different  $\xi$  (moving along the x-axis) holding  $\chi$  at the calibrated value, and panel B shows the impact of reducing  $\psi$  for different  $\chi$  (moving along the x-axis) holding  $\xi$  at the calibrated value. Panels C and D present the percentage increase in steady-state GDP when  $\xi$  is reduced from its calibrated value of 0.335 to 0.29, interacting with different values of  $\psi$  and  $\chi$ . Panels E and F present the percentage increase in steady-state GDP when  $\chi$  is reduced from its calibrated value of 0.04 to 0, interacting with different values of  $\psi$  and  $\xi$ .

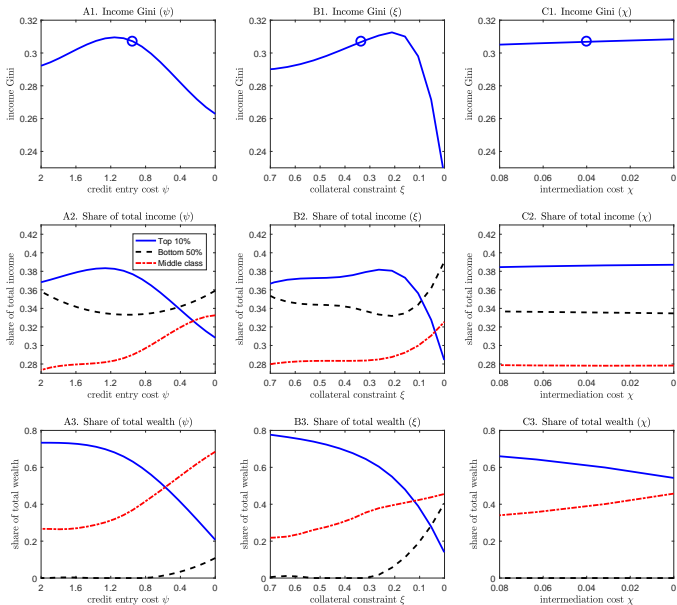
# Distributional implications of financial inclusion

- ▶ We calculate the consumption-equivalent welfare gains in steady states after relaxing financial constraints.



- ▶ Relaxing different constraints has different implications on different agents.
  - ▶ Largely depends on agents' wealth and productivity.
- ▶ Reducing the credit entry cost benefits every agent in the economy.
- ▶ The welfare of some agents will fall when the collateral constraint is relaxed or when the intermediation cost is reduced due to GE effects (white region).

# The distribution of income and wealth





# Identifying the most binding constraint

We calibrate the model to six representative countries.

- ▶ Pakistan, Bangladesh, Brazil have relatively extreme financial constraints.
- ▶ The Philippines, Kenya, Zambia have relatively balanced financial constraints.
  - ▶ Difficult to tell which financial constraint is most binding simply by looking at the descriptive statistics.

	Moments in data and model in various countries											
	Pakistan		Bangladesh		Brazil		The Philippines		Kenya		Zambia	
	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
Firms with credit (%)	6.7	6.7	34.1	34.7	59.2	59.8	29.9	29.5	25.4	25.9	8.8	8.6
Collateral (% of loans)	153.4	154.0	271.4	271.7	95.1	100.4	156.7	156.4	120.8	120.8	236.6	236.4
Interest rate spread (%)	4.8	4.7	1.9	1.9	35.4	35.4	4.0	4.0	8.5	8.5	11.8	11.8
Real interest rate (%)	0.2	0.5	4.5	4.6	2.9	2.8	6.2	6.3	7.6	7.7	4.8	4.5
Employment share of Top 5% (%)	65.7	52.1	55.4	50.3	63.1	66.4	43.7	43.7	54.1	53.9	41.8	35.9
Employment share of Top 10% (%)	77.6	60.9	71.2	61.5	74.6	80.6	57.6	58.6	66.9	69.1	56.1	49.9
Employment share of Top 20% (%)	87.6	70.2	86.2	85.8	84.7	87.1	73.2	71.5	81	73.4	70.7	63.3
Employment share of Top 40% (%)	94.7	91.4	95.2	96.6	93.1	95.9	88.8	85.3	93.2	84.9	84.7	89.0
Gross savings (% of GDP)	21.4	20.5	21.2	20.6	23.9	28.5	44.2	41.2	15.4	14.9	35.4	29.6

We investigate what would happen when one of the constraint is relaxed.

- ▶ This does not mean the government should only alleviate one single constraint.
- ▶ This sort of experiment gives us the “sensitivity” of GDP/TFP to each constraint → the most binding constraint has the highest sensitivity.

# Identifying the most binding constraint (continued)

	Impact of financial inclusion on GDP, TFP and income Gini								
	$\psi \rightarrow 0$			$\xi \rightarrow 0$			$\chi \rightarrow 0$		
	GDP(%)	TFP(%)	Gini	GDP(%)	TFP(%)	Gini	GDP(%)	TFP(%)	Gini
Pakistan	24.96	9.71	-0.021	89.71	55.59	-0.082	0.11	0.01	0.001
Bangladesh	8.94	2.33	0.008	111.92	77.48	-0.124	0.50	0.41	0.002
Brazil	0.02	0.01	-0.000	0.00	0.00	0.000	42.44	38.31	0.056
The Philippines	9.25	4.78	-0.046	59.73	37.42	-0.083	0.70	0.50	0.002
Kenya	21.01	11.70	-0.060	13.77	7.83	-0.020	2.41	0.91	0.012
Zambia	10.22	5.34	-0.003	81.85	47.76	-0.059	1.50	1.13	0.002

For the three countries with extreme financial constraints:

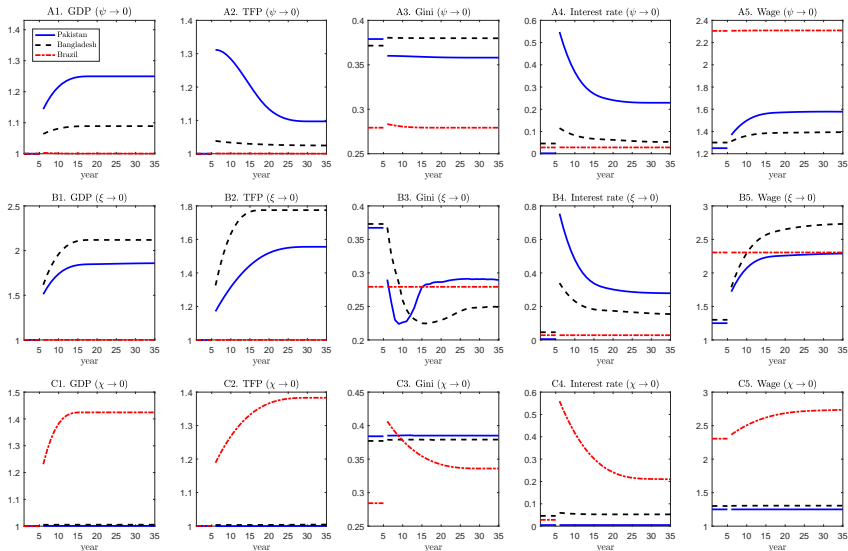
- ▶ Descriptive stats could be informative:
  - ▶ Reducing  $\chi$  in Brazil is most effective, reflected by its high interest rate spread.
  - ▶ Reducing  $\xi$  in Bangladesh is effective, reflected by its tight collateral constraint.
- ▶ Choosing policies entirely based on descriptive stats could be misleading:
  - ▶ Reducing  $\xi$  rather than  $\psi$  is most effective in Pakistan, even though the country's credit access ratio is low.
  - ▶ Reason: the credit access ratio is endogenously determined in equilibrium.

For the three countries with balanced financial constraints:

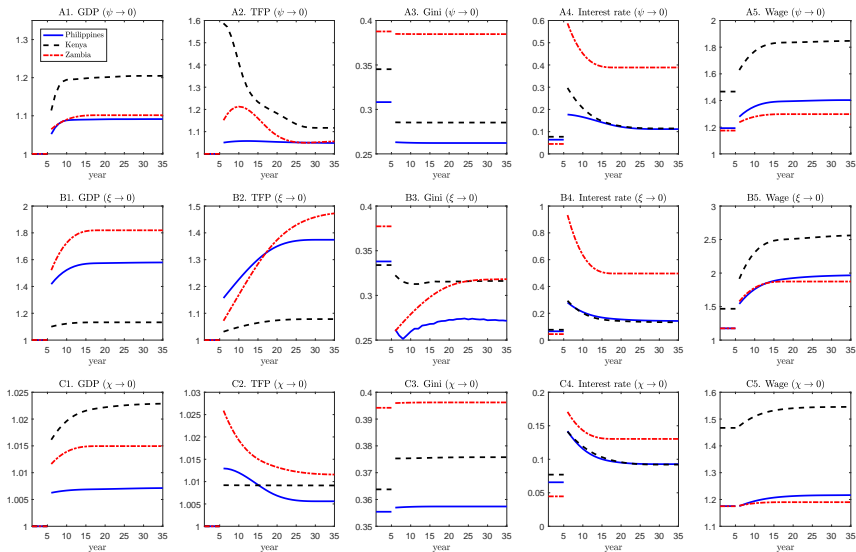
- ▶ The model allows us to systematically evaluate the potential impacts of different policies to shed light on the real underlying bottleneck.

# Transitional dynamics after financial inclusion

- ▶ Reforms are implemented unexpectedly in a steady-state economy in year 5.



# Transitional dynamics after financial inclusion



# Transitional dynamics: interest, wage, and GDP

---

- ▶ Transition is gradual because reallocation of capital is through imperfect financial markets (Jermann and Quadrini, 2007; Buera and Shin, 2011).
- ▶ For the simulated path of transitional dynamics in each country, we observe overshooting in the equilibrium interest rate.
  - ▶ The interest rate in the short run is higher than that in the long run after financial inclusion (see panels A4, B4, and C4)
- ▶ There is no overshooting of the equilibrium wage.
  - ▶ The equilibrium wage surges in year 5, reflecting the immediate increase in demand for workers when constraints are relaxed.
  - ▶ The equilibrium wage steadily increases thereafter to reach its new steady-state value due to the gradual accumulation and reallocation of capital.
- ▶ GDP increases substantially in year 5 and more gradually thereafter.
  - ▶ The positive effect of financial inclusion on GDP is larger in the long run than in the short run.
  - ▶ Intuitively, it takes time for entrepreneurs to accumulate wealth to fully reap the gains from financial inclusion policies.

# Transitional dynamics: TFP

---

- ▶ Reducing the credit entry cost  $\psi$  to zero generates overshooting in the short-run dynamics in many countries (panel A2).
  - ▶ The overshooting may happen with a lag in some countries (see the red dash-dotted line for Zambia in panel A2).
- ▶ Relaxing the collateral constraint  $\xi$  to zero does not generate an overshooting effect (panel B2).
  - ▶ In all six countries, TFP surges in year 5 before plateauing to reach its new steady-state value.
- ▶ Reducing the intermediation cost generates a clear overshooting effect in Philippines and Zambia (panel C2).

# Transitional dynamics: income inequality

---

- ▶ Reducing the credit entry cost  $\psi$  may lead to a higher or a lower long-run Gini coefficient, depending on the country (panel A3).
- ▶ Relaxing the collateral constraint  $\xi$  results in a lower Gini coefficient in the long run, and overshooting occurs in the short run (panel B3).
- ▶ Reducing the intermediation cost  $\chi$  leads to a higher Gini coefficient in the long run (panel C3).
  - ▶ In Brazil, reducing the intermediation cost leads to higher GDP and income inequality. However, the effect on GDP is smaller in the short run than in the long run whereas the opposite is true for income inequality (see the red dash-dotted line in panel C3 ).

# Welfare gains during transitions

	$\psi \rightarrow 0$			$\xi \rightarrow 0$			$\chi \rightarrow 0$		
	$t' = 0$	$t' = -10$	$t' = -\infty$	$t' = 0$	$t' = -10$	$t' = -\infty$	$t' = 0$	$t' = -10$	$t' = -\infty$
Pakistan (%)	4.85	7.40	7.96	16.39	23.68	25.95	0.67	1.80	2.06
Bangladesh (%)	2.08	2.90	3.12	39.50	61.54	62.22	0.19	0.28	0.94
Brazil (%)	0.79	0.79	0.80	0.00	0.00	0.000	45.59	62.15	70.46
The Philippines (%)	3.95	4.98	5.29	17.39	22.65	25.10	1.17	2.05	2.50
Kenya (%)	3.87	4.68	4.94	14.78	18.86	20.35	3.88	6.73	8.22
Zambia (%)	2.70	4.27	4.36	13.73	20.61	20.85	0.49	1.18	1.27

- ▶  $t' = 0$ : welfare gains immediately after financial inclusion.
- ▶  $t' = -10$ : welfare gains 10 years after financial inclusion.
- ▶  $t' = -\infty$ : welfare gains in the new steady state after financial inclusion.



# Application: policy evaluation in Thailand

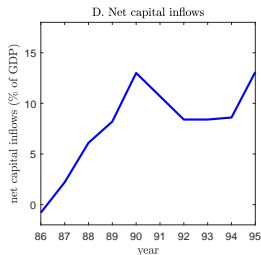
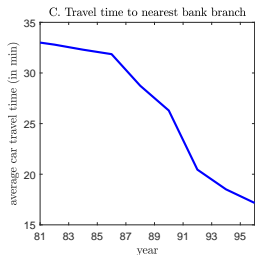
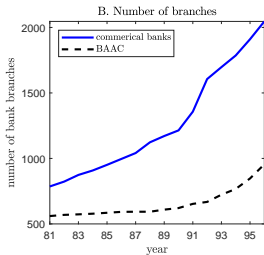
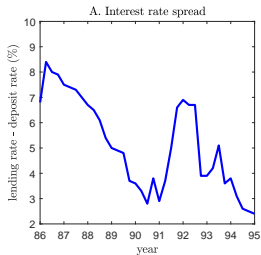
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- ▶ Between 1986-1996, Thailand's economy underwent deep structural changes.
  - ▶ Sharp decrease in the interest rate spread.
  - ▶ Fast expansion of bank branch networks.
  - ▶ A surge in private capital inflows and rapid credit growth.
- ▶ We calibrate the model to reflect these trends in the Thai financial system.

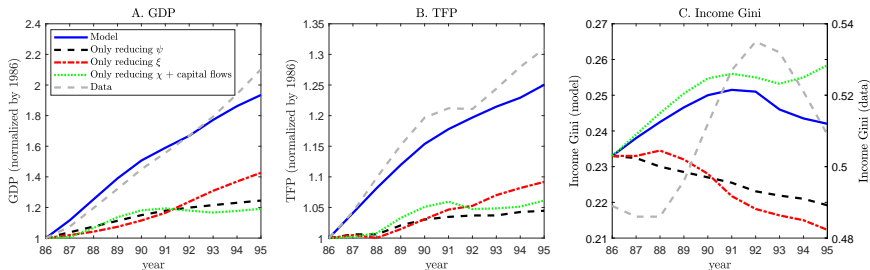
	86	87	88	89	90	91	92	93	94	95
$\chi_t$ (%)	8.00	7.70	6.88	5.35	3.85	3.30	6.30	4.68	3.90	2.40
$\varsigma_t$ (%)	-0.80	2.20	6.10	8.20	13.00	10.70	8.40	8.40	8.60	13.10
$\psi_t$	0.72	0.64	0.56	0.48	0.40	0.32	0.24	0.16	0.08	0
$\xi_t$	0.9	0.82	0.74	0.66	0.58	0.51	0.43	0.35	0.27	0.19

- ▶  $\chi_t$ : the average annualized quarterly interest rate spread in year  $t$ .
- ▶  $\varsigma_t$ : net capital flows as a percentage of GDP in year  $t$ .
- ▶  $\psi_t$ : credit access ratio is 10% in 1986;  $\psi_t$  decreases by the same amount in each year until it vanishes in 1996.
- ▶  $\xi_t$ : set at 0.9 in 1996 and decreases by the same amount until it reaches 0.19 in 1996, which matches the median loan-to-collateral ratio in the 1997 survey.

# Access to formal finance in Thailand, 1981-1996



# Model-based evaluation



- ▶ In each counterfactual experiment, we allow  $\psi_t$ ,  $\xi_t$ , or  $\chi_t$  (plus  $\varsigma_t$ ) to vary over time while keeping the other two parameters fixed at their values in 1986.
  - ▶ If only the collateral constraint is relaxed, GDP increases by about 42.7%, TFP by 9.2%, and income Gini decreases (the red dash-dotted lines).
  - ▶ Reducing the credit entry cost alone increases GDP by about 24.5%, TFP by about 4.5%, and income Gini decreases (the black dashed lines)
  - ▶ Reducing the cost of credit increases GDP by about 19.1% and TFP by 6.1%, and income Gini increases (the green dotted lines).
  - ▶ The lower cost of credit increases Gini whereas the lower credit entry cost and relaxed collateral constraint reduce Gini (panel C).

# Conclusion

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- ▶ A model featuring multiple realistic sources of financial frictions.
- ▶ The impact of financial inclusion policies depends not only on which constraint is alleviated but also on the tightness of other constraints.
  - ▶ Though financial inclusion policies may target the most binding constraint, this can vary across countries in ways that may not be obvious, apriori.
- ▶ There are tradeoffs between financial inclusion, GDP, and the distribution of income when conducting financial inclusion policies.
- ▶ There are inter-temporal tradeoffs and policy commitment issues.
  - ▶ Some variables move in the short term in the opposite direction from their longer run impact.

## **Lecture 8: Multiple Obstacles in Economy-Wide Models: Realistic vs Ad Hoc, with Policy Implications (4/2)**

\*Moll, Benjamin, Robert M. Townsend, and Victor Zhorin. "Economic development, flow of funds, and the equilibrium interaction of financial frictions." *Proceedings of the National Academy of Sciences* 114.24 (2017): 6176-6184.

\*Era Dabla-Norris & Yan Ji & Robert M. Townsend & D. Filiz Unsal, 2015. "Distinguishing Constraints on Financial Inclusion and Their Impact on GDP, TFP, and Inequality," NBER Working Papers 20821, National Bureau of Economic Research, Inc.

Flow of Funds Within and Across Countries

Cole, H. L., Greenwood, J. and Sanchez, J. M. (2016), Why Doesn't Technology Flow From Rich to Poor Countries? *Econometrica*, 84: 1477-1521. doi:10.3982/ECTA11150