Big Push in Distorted Economies

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Motivation

- Large income per capita differences across countries
- "Explained" by productivity differences
- Large differences in the size of establishments/firms
  (Hsieh/Klenow, Bento/Restuccia)
- Two views
  (1) Barriers to technology adoption, distortions $\Longrightarrow$ Requires large distortions
  (Parente/Prescott, Restuccia/Rogerson, Hsieh/Klenow)
  (2) Complementarities, coordination failures
  (Rosenstein-Rodan, Hirschman, Murphy/Shleifer/Vishny)
- In this paper, we integrate these views

  We study how complementarities amplify distortions $\Longrightarrow$ small distortions can have large effects $\Longrightarrow$ BIG PUSH

Road Map

1. Model of firm entry, technology adoption, input-output linkage, idiosyncratic distortions
   - Standard model of firm entry and technology adoption
   - Elements of Murphy et al. (1989), Matsuyama (1995), Ciccone (2002), Jones (2011)
2. Quantitative exploration
   - Guided by aggregate and microdata from the US and India
3. Can there be large effects of distortions and policies? YES, in Big Push region, without multiple equilibria
4. Can development be a story of multiple equilibria? NO, but possible in highly distorted economies

Model Economy: Summary

- Ex-ante heterogeneous potential entrants, $z \sim F(z)$

- Monopolistically competitive, differentiated goods

- Idiosyncratic correlated distortions , $\tau(z) = 1 - \tau z^{-\xi}$

- Labor cost of entry, labor and goods cost of adoption

- Produce using labor and intermediate inputs

Intermediate Aggregate/Final Good Producers

- CRS technology using differentiated intermediates $j \in [0, 1]$

$$X = \left[\int y(j)^{\frac{\eta-1}{\eta}} dj \right]^{\frac{\eta}{\eta-1}}$$

- Used for final consumption, intermediate inputs, and for adoption investment

$$C + \int x(j) dj + \# \text{ of adopters} \times \kappa_a = X$$

Intermediate Good Producers

CRS technologies $i \in \{t, m\}$

$$\begin{aligned} y =& f_i(z, x, l) \\ =& z \underbrace{\frac{A_i}{\nu_i^{\nu_i}(1-\nu_i)^{1-\nu_i}}}_{\bar{A}_i} x^{\nu_i} l^{1-\nu_i}, \ \bar{A}_t < \bar{A}_m, \ \nu_t \leq \nu_m \end{aligned}$$

,

- z: heterogeneous productivity
- x : intermediate input
- l : labor input
- m: Modern, A_m, labor entry costs κ_e, goods costs of adoption κ_a
- t: Traditional, A_t, only labor entry cost κ_e

Intermediate Good Producers' Problem

Monopolistically competitive

$$\pi_i^o(z) = \max_{p,x,l} \tau z^{-\xi} p \underbrace{\left(\frac{P}{p}\right)^{\eta} X}_{q} - Px - wl$$

s.t.

$$f_i(z,x,l) \geq q.$$

Equilibrium: P, w, z_e and z_a such that

The marginal entrant z_e

$$\pi_t^o(z_e) = w\kappa_e;$$

The marginal adopter z_a

$$\pi_m^o(z_a) - \pi_t^o(z_a) = P\kappa_a;$$

Labor market clearing

$$\int_{z_e}^{z_a} l_t(z)dF(z) + \int_{z_a}^{\infty} l_m(z)dF(z) = L - (1 - F(z_e))\kappa_e$$

The price of the intermediate aggregate

$$P = \left[\int_{z_e}^{z_a} p_t(z)^{1-\eta}dF(z) + \int_{z_a}^{\infty} p_m(z)^{1-\eta}dF(z)\right]^{\frac{1}{1-\eta}}$$

Complementarity in Technology Adoption

When more firms adopt the productive technology, for the marginal firm:

1. Price index falls ($\downarrow P$)
2. Demand for its output increases
3. Intermediate input becomes cheaper
4. Adoption cost falls

If 2+3+4 stronger than 1, gains from adoption increase in the number of adopters: *complementarity* in adoption decisions.

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Complementarity stronger when

- Differentiated goods less substitutable (small η)
- Higher intermediate input intensity of the modern technology ($\nu_m > \nu_t$)
- Bigger share of goods in innovation cost

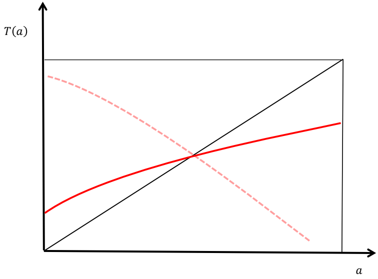
Understanding Amplification & Multiplicity

- $D(z;a) \equiv \overbrace{\pi_m^o(z;a) - \pi_t^o(z;a)}^{\equiv \Delta\pi(z;a)} - P(a)\kappa_a$
  (gain from adoption for z when fraction a adopted)

- Equilibrium "best response" mapping

$$T(a) = \{a' | a' = (1 - F(z_a)) \text{ and } D(z_a;a) = 0\}$$

Unique Equilibrium



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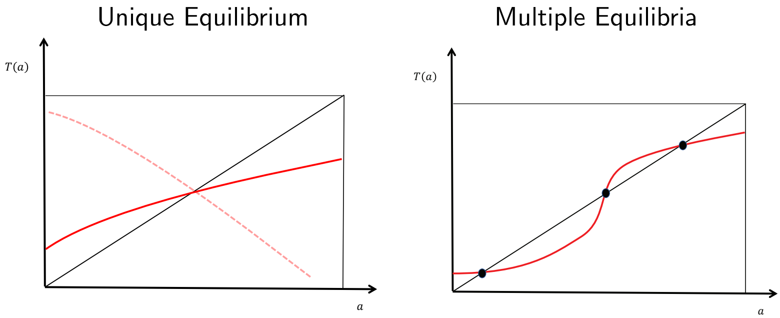


- Multiplicity requires $T'(a) > 1$

Amplification

Consider the effect of a decrease in the cost of adoption κ_a

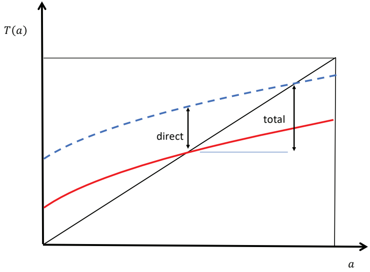
- Multiplier:

$$\frac{\overbrace{dz_a/d\kappa_a}^{\text{total effect}}}{\underbrace{dz_a^d/d\kappa_a}_{\text{direct effect}}} = \frac{1}{1 - \underbrace{\frac{D_a(z_a;a)f(z_a)}{D_z(z_a;a)}}_{\text{Amplification rate } = r(z_a, a)}}$$

$\rightarrow$ Amplification if $r(z_a, a) > 0$

- $T'(a) = r(z_a, a)$, where z_a satisfies $a = 1 - F(z_a)$

Amplification



- $r(z_a, a) = T'(a) = \frac{D_a(z_a;a)f(z_a)}{D_z(z_a;a)}$
- Even without multiplicity, amplification could be strong, the steeper the slope $T'(a) \in (0, 1)$

Determinants of Amplification rate

$$\overbrace{r(z_a,a)}^{\text{Amplification rate}} = \overbrace{\frac{dD(z_a)}{da}\frac{a}{\Delta\pi(z_a)}}^{\text{Incentive elasticity}} \overbrace{\left[\frac{dz_a}{dD(z_a)}\frac{\Delta\pi(z_a)}{z_a}\right]\frac{f(z_a)z_a}{a}}^{\text{Feedback}}$$

$$= \frac{dD(z_a)}{da}\frac{a}{\Delta\pi(z_a)}\frac{1}{\eta(1-\xi)-1}\zeta$$

- Incentive: effect of change in mass of adopters on net gains from adoption for marginal adopter

- Feedback: effect of change in net gains of adoption on identity of marginal adopter

  - $\uparrow \eta$: $\uparrow$ demand elast.$\Rightarrow$ higher reaction to own $z \Rightarrow \downarrow r(z_a,a)$
  - Higher feedback when distortions ξ are higher
  - ζ translates the change in z_a to the adoption rate

Amplification & Multiplicity, $\nu_m = \nu_t = \nu$

Suppose $\xi = 0$. Then,

$$r(z_a, a) = \frac{1}{1-\nu}\left(\frac{2-\eta}{\eta-1} + \nu\right)\left(\frac{\zeta-(\eta-1)}{\eta-1}\right)\mathcal{M}(a)\left[1 - \left(\frac{A_t}{A_m}\right)^{\eta-1}\right]$$

- Amplification requires $r(z_a, a) > 0$. This occurs iff

  $$\eta < \frac{2-\nu}{1-\nu}$$

  when η is low, the (-) competition effect is low, and thus the positive effects on the gains of adoption dominate

- Multiplicity requires $r(z_a, a) > 1$. A necessary condition is

  $$\eta < \frac{2 + \frac{1-\nu}{1+\zeta} - \nu}{1 + \frac{1-\nu}{1+\zeta} - \nu}$$

  Stronger condition! It must also countervail the negative effects of heterogeneity

Quantitative Exploration

1. Parameterize the model with US plant/firm level data
2. Choose idiosyncratic distortions to match data from India
3. Explore how complementarities amplify distortions and policies
4. Explore set of equilibria, in the calibrations and more broadly
5. Quantify the role of coordination failures on GDP

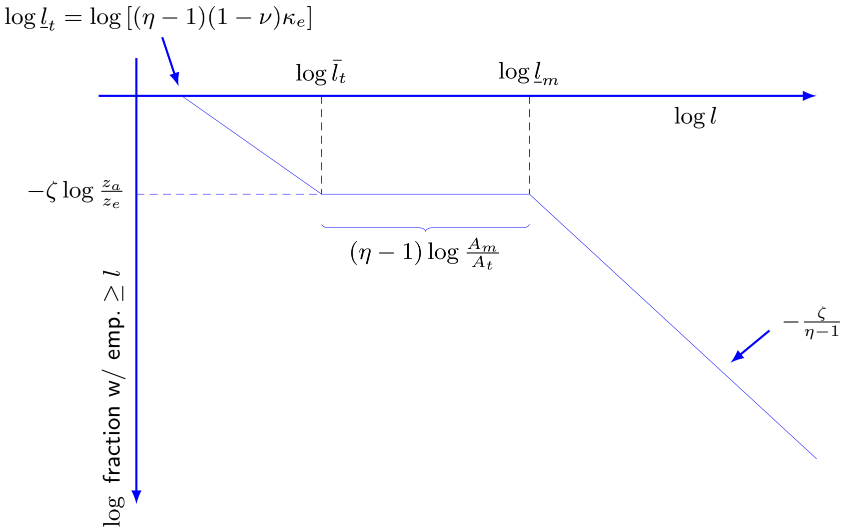
Parameterization

$$(A_m, \eta, \nu_t, \nu_m, \zeta, A_t, \kappa_e, \kappa_a, \xi)$$

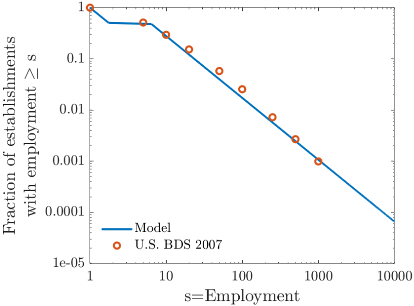
- A_m normalized to 1
- $\eta = 3$, comparison w/ Hsieh & Klenow (2009)
- (ν_t, ν_m) jointly determine aggregate share of intermediate goods.
  - $\nu_t = 0$, traditional technology labor only
- ξ assumed zero in the US
- $(\zeta, A_t, \kappa_e, \kappa_a, \xi)$ chosen to match size distribution
- Point identification with data on the size distribution of firms
- Key identification assumption: both technologies are observed in equilibrium

Identification: given η, $\nu_t = \nu_m$, and $\xi = 0$

Figure: Identification from the establishment size distribution



Parameterization

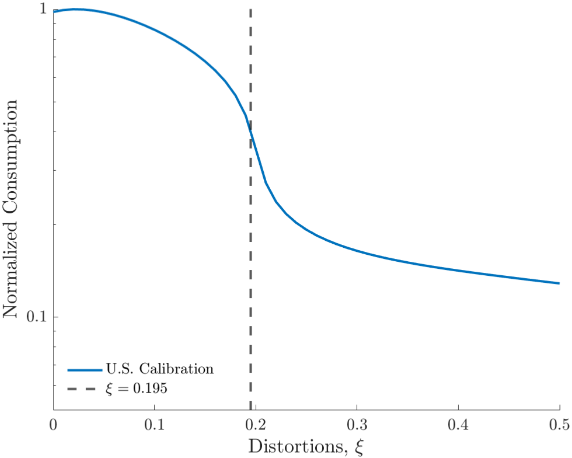


- Obtain $\zeta = 2.4$ (Pareto tail) and $\nu_m = 0.7$, $A_t/A_m = 0.43$

  $y = z\frac{A_i}{\nu_i^{\nu_i}(1-\nu_i)^{1-\nu_i}}x^{\nu_i}l^{1-\nu_i}$, $i = t, m$

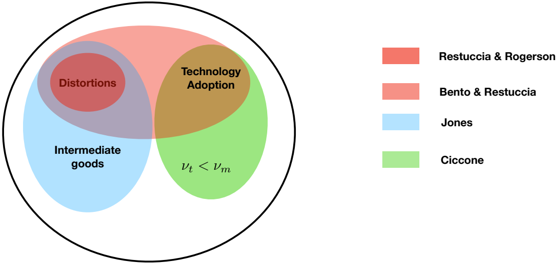
- Average est. size: 19 employees; 50% of entrants adopt

Impact of Idiosyncratic Distortions



Impact of Idiosyncratic Distortions

- Start from the US, introduce idiosyncratic distortions ($\xi > 0$)
- Unpack the role of model elements

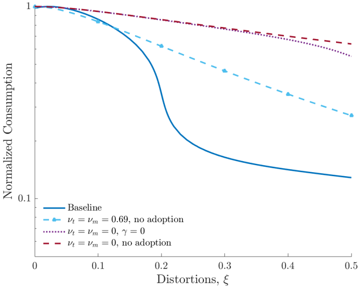


- For amplification/multiplicity, none is essential theoretically (other than adoption) but their interaction matters quantitatively

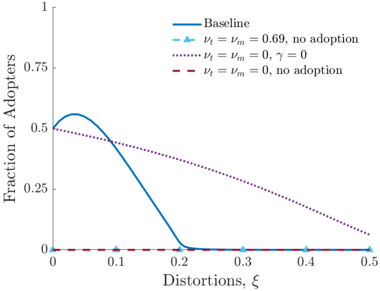
Impact of Idiosyncratic Distortions I

Starting from the US ($\xi = 0$)

Consumption



Adoption

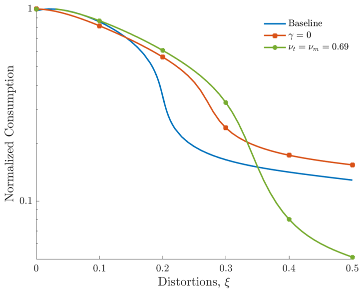


- Locally nonlinear effect in the benchmark (Big Push region)
- Adoption costs increase endogenously
- More entry but lower adoption rates Average Size

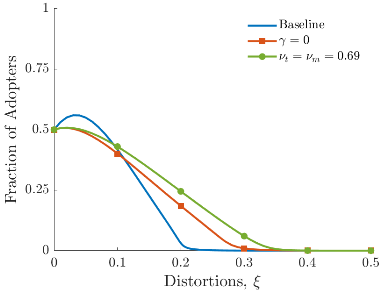
Impact of Idiosyncratic Distortions II

Starting from the US ($\xi = 0$)

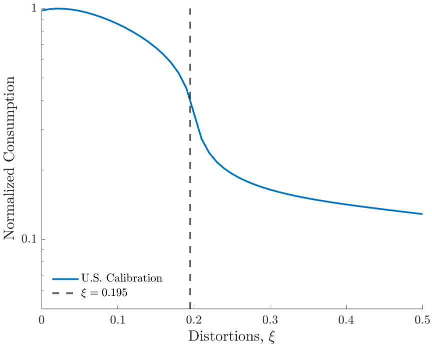
Consumption



Adoption



Gap between the US and India



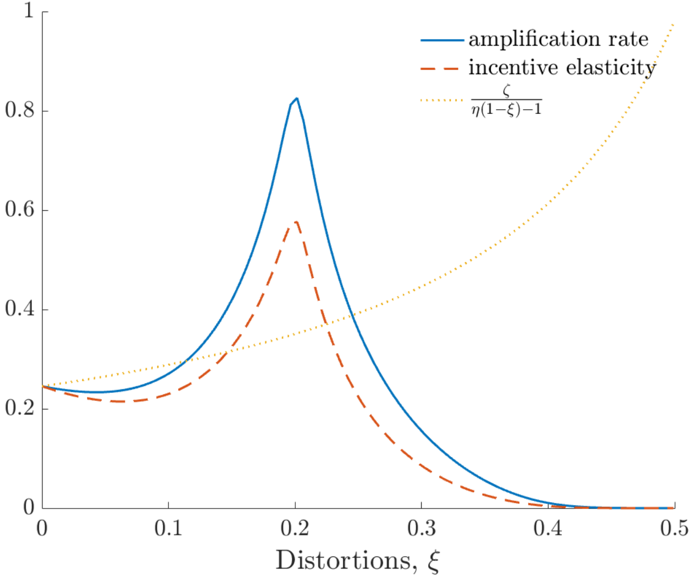
- Assume the only difference for India is idiosyncratic distortions, pinned down by the tail of est. size distribution ($\xi = 0.195$)
- Adoption cost endogenously up by 30%
- Setting $\xi = 0 \Rightarrow$ Aggregate consumption jumps by 144%
- Small reform can have disproportionate effects
- No multiplicity

Understanding the Gap

Case	In Model	Relative Cons
Benchmark		0.41
Labor innovation cost	$\gamma = 0$	0.49
Same intermediate good share	$\nu_t = \nu_m$	0.62
Jones	$\nu_t = \nu_m$, ~~adopt~~	0.63
Bento & Restuccia	$\nu = 0, \gamma = 0$	0.85
Restuccia & Rogerson	$\nu = 0$, ~~adopt~~	0.86

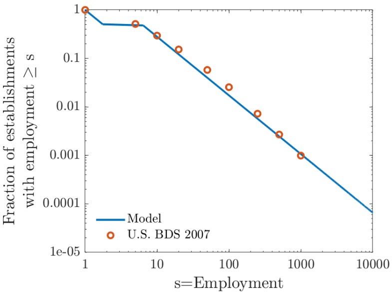
(Consumption with $\xi = 0.195$ over consumption with $\xi = 0$)

Amplification rate: Quantitative Model

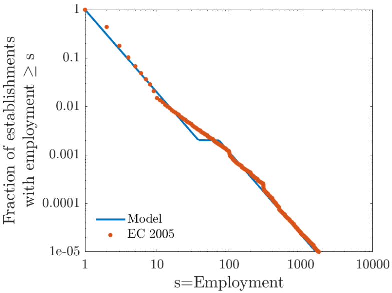


Full parameterization for India

US



India, Economic Census

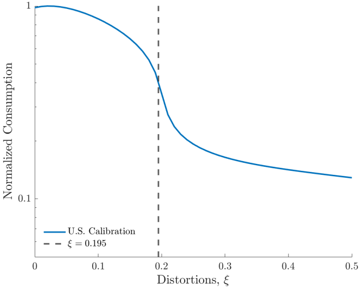


India parameterization:

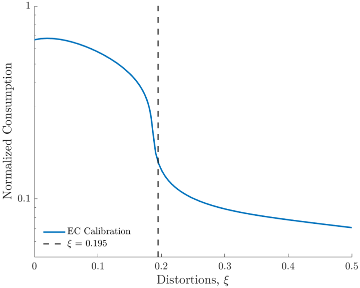
- higher κ_a (and ξ),
- lower A_t

Impact of Idiosyncratic Distortions III

US calibration



India, EC Calibration



Understanding the Gap

Case	In Model	Relative Cons
Full India		0.15
Benchmark		0.41
Labor innovation cost	$\gamma = 0$	0.49
Same intermediate good share	$\nu_t = \nu_m$	0.62
Jones	$\nu_t = \nu_m$, n/adopt	0.63
Bento & Restuccia	$\nu = 0, \gamma = 0$	0.85
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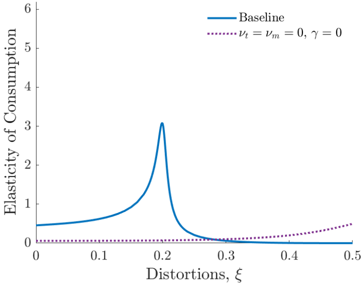
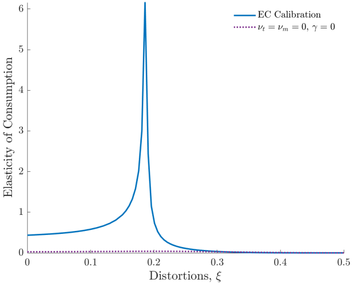
Industrial Policy, Distortions, and the Big Push

- Subsidize the price of the adoption good: $P\kappa_a \implies (1 - {\color{red}s})P\kappa_a$

US

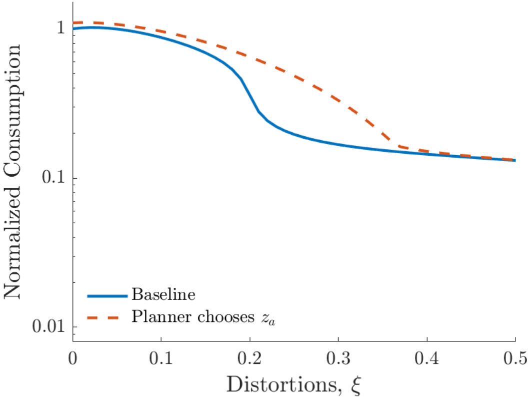


India



Constrained Planner - US

- Planner that controls z_a and takes distortions as given

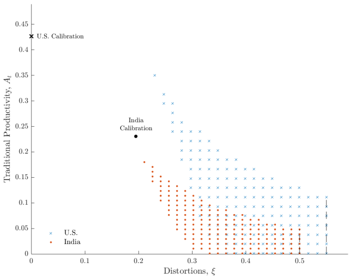


- Biggest gains are in Big Push region

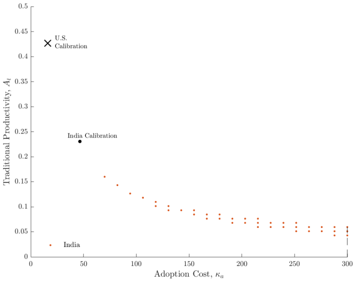
Region of Multiple Equilibria

- Multiplicity requires low A_t, *and* high κ_a and ξ
- India has different κ_a, A_t, as well as ξ, closer to multiplicity

Fixed κ_a

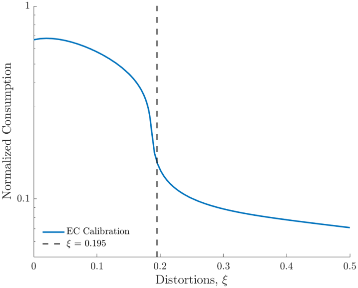


Fixed ξ

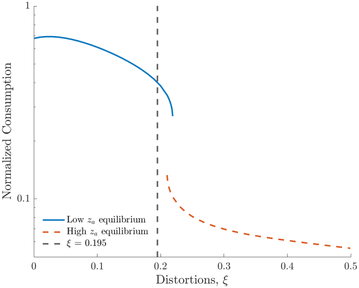


Consumption and Multiplicity

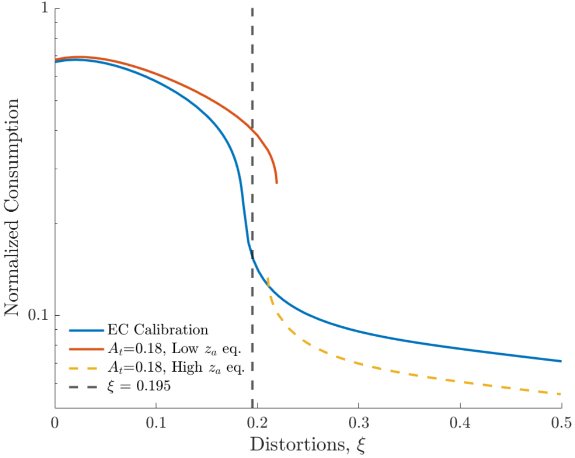
India, EC Calibration



India, nearest multiplicity



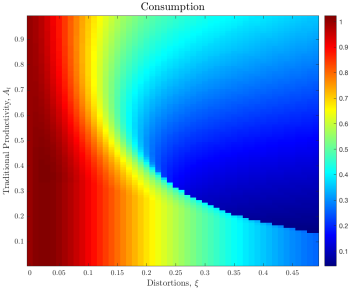
Consumption and Multiplicity



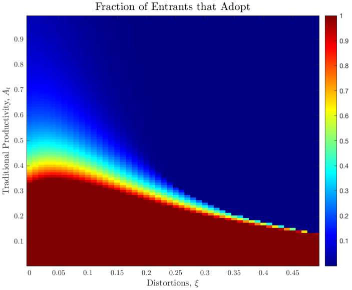
How Robust is Big Push (I)

- Fix $\kappa_a = 15.93$ (US value)
- In region with multiple equilibria, plot the good equilibrium

Normalized consumption



Adoption rates



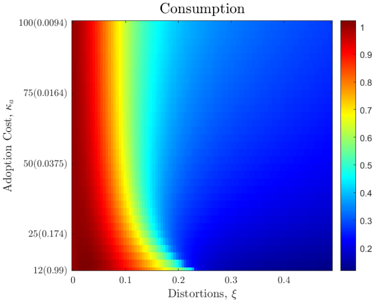
Consumption level

- Big push occurs for a large set of A_t

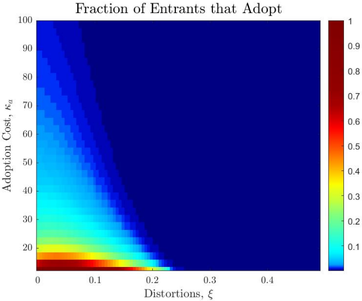
How Robust is Big Push (II)

- Fix $A_t = 0.43$ (US value)
- In region with multiple equilibria, plot the good equilibrium

Normalized consumption



Adoption rates

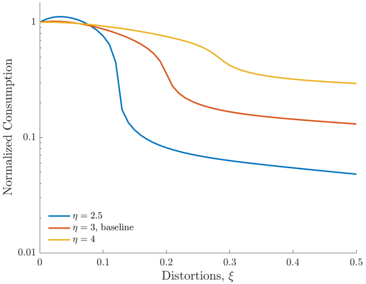


Consumption level

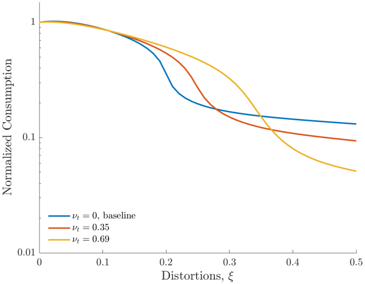
- Big push occurs for a large set of κ_a

Robustness of Big Push to Alternative Values of η and ν_t

Alternative η



Alternative ν_t

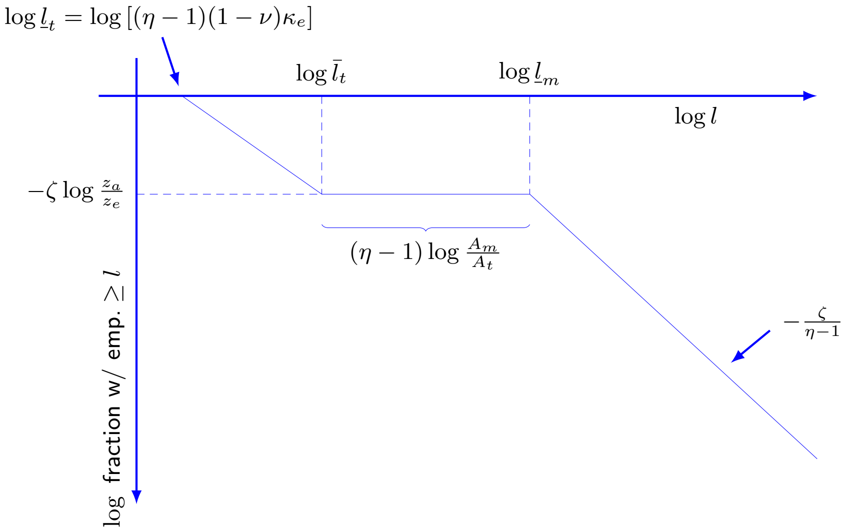


Wrapping Up

- Can there be large effects of distortions and policies?
  Yes, even without multiple equilibria
  - Complementarities $\Longrightarrow$ Feedbacks, amplifying the effect of distortions/policies, with or without multiplicity
  - Nonlinear effects in the Big Push region
- Can development be a story of (lack of) coordination?
  Yes, for economies with *enough distortions*

Identification: given η, $\nu_t = \nu_m$, and $\xi = 0$

Figure: Identification from the establishment size distribution



Calibrated Parameters

Parameter	US	India
Elasticity of substitution, η	3	
Intermediate agg. share in adoption good production, γ	1	
Productivity distribution Pareto tail parameter, ζ	2.42	
Modern technology productivity, A_m	1	
Modern technology intermediate input elasticity ν_m	0.70	
Traditional technology intermediate input elasticity, ν_t	0	
Entry cost, κ_e	0.50	0.50
Traditional technology, A_t	0.43	0.23
Adoption cost,		
κ_a	15.93	46.54
$P\kappa_a$	9.36	101.4
Degree of distortions, ξ	0	0.19
Distortion scale parameter, τ	1	1.61

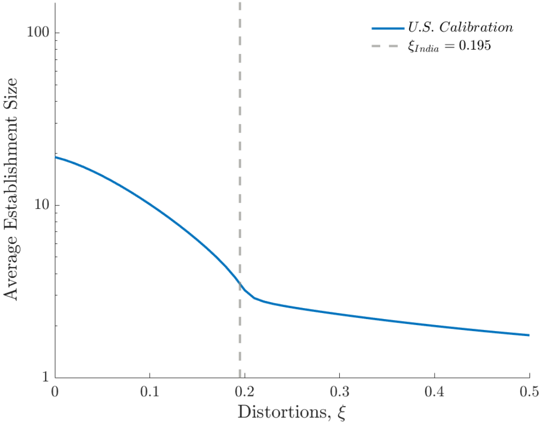
Aggregate Moments

	US	India
Fraction of active firms (out of 1)	0.05	0.32
Fraction of active firms that adopt A_m	0.5	0.001
Average establishment size	19.0	2.4
Aggregate Consumption	1	0.15

- India's GDP per worker in 2005 is 6% of US (Penn World Tables)

Impact on Average Size

United States



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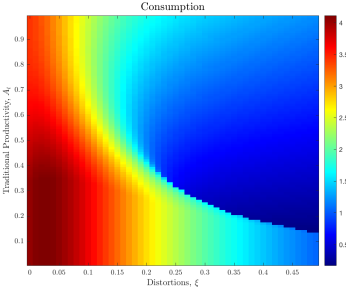
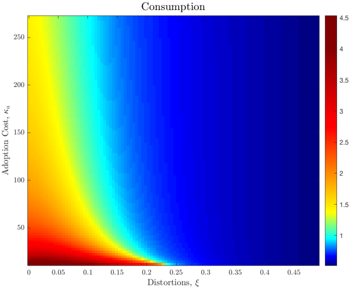
How robust is Big Push - consumption level

Fix κ_a



Fix A_t



A_t exercise κ_a exercise