Aggregate Effects of SEZs: A Firm Dynamics Model with Endogenous Entry, Exit and Location Choices

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What is a Special Economic Zone (SEZ)?

A location where firms are subject to these benefits and dues:

1. Corporate taxes are lower: 20% SEZ $<$ 33% NSEZ.
2. Credit access is larger: SEZ firms are more likely to get credit.
3. Keep a minimum scale (profit) requirement.

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2. What is the optimal size of SEZs?

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- New stylized facts for firm dynamics and SEZs.

(2) Firm dynamics model with endogeneous entry, exit and location (zone) choices:

- Aggregate effects of SEZs
- SEZ channels one-by-one
- Optimal size of SEZs (optimal corporate taxes).

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2. Through model counterfactuals:
   - ▷ SEZs increase aggregate TFP by 25.7%.
     (1) Selection (average z_i increases by 25.1%),
     (2) Accumulation (average k_i increases by 12.8%)
     (3) Within-firm resource allocation (average $cov_i(z, k)$ by 88%)

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   - ▷ About 1/2 of the improved selection, resource allocation and investment is driven by the reduction of financial frictions.

Literature

- Empirical evidence of SEZs on TFP growth, investment (city-level): Wang (2013); Alder et al. (2016); Schminke and Biesebroeck (2011)
  - micro variation within cities, and within SEZs.
- Agglomeration/Selection effect: Marshall (1890); Jacobs (1969); Combes et al. (2012)
  - selection plays the main role in China.
- Firm dynamics, entry barriers, selection: Hopenhayn (1992); Khan and Thomas (2011); Lagakos and Waugh (2013); Restuccia and Rogerson (2008)
  - endogenous entry and discrete SEZ location choices.
- Resource misallocation, selection models: Restuccia and Rogerson (2008); Hsieh and Klenow (2009); Adamopoulos et al. (2023)
  - dynamics (investment) and agglomeration effects.

New Panel Data and Stylized Facts

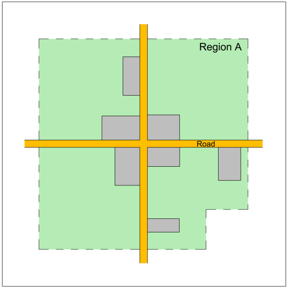
New Firm-Level Panel Data

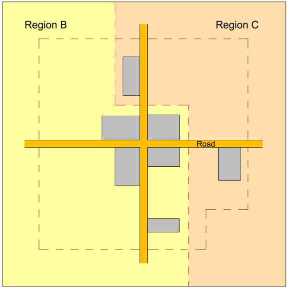
Construction

(1) Main dataset: ASIF collected by (NBS) over 1998-2013.

  1.1 Firms annual sales > 5 million RMB

  1.2 Unify county-level code at firm-level data
  using "street name", "community name" to unify the county code as the administrative division code of 2013.





New Firm-Level Panel Data

Construction

(2) China Development Zone Review Announcement List (2018) + official sources

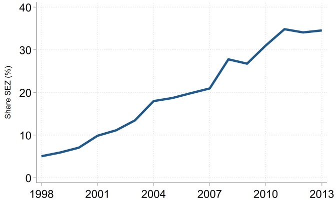
- **2.1** Information: zone's name, zone size, **approval time**, dominant industries.
- **2.2** Lack of location: GIS map, find the address of SEZs based on its name. Coded with county ID.

My constructed dataset contains 586,599 unique firms over 1998-2013 in 2,574 counties.

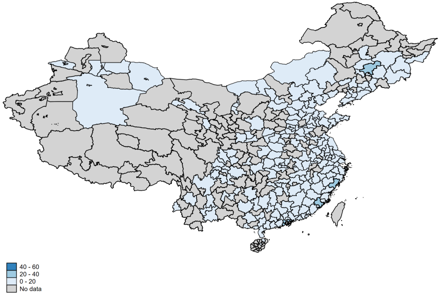
SEZs in China: Evolution Across Time and Space

Deng Xiaoping: *"Crossing the river by touching the stones"*

Share of Firms in SEZs



Year: 1998



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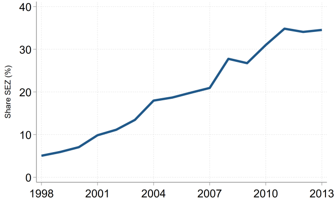

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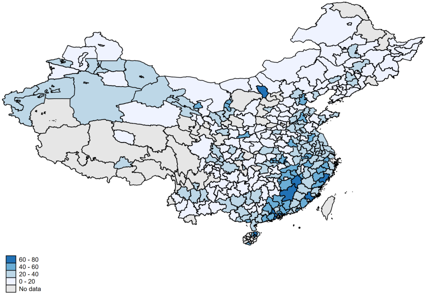
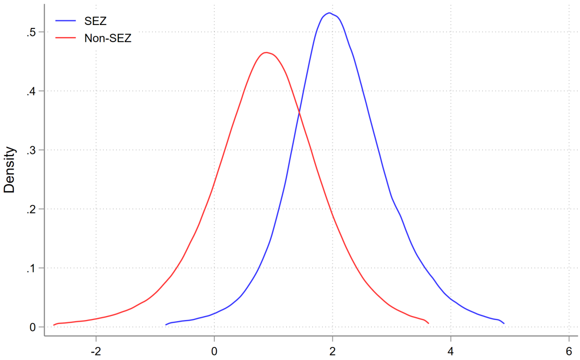


Stylized Fact 1: Better performance in SEZ

SF1: Average firm TFP in SEZ is 136% larger than in NSEZ.

Firm-Level TFP ($log(Z_i)$)



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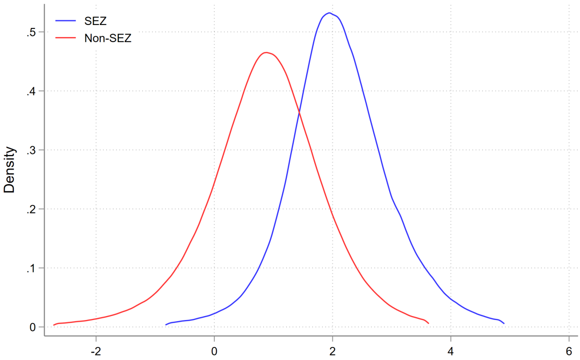
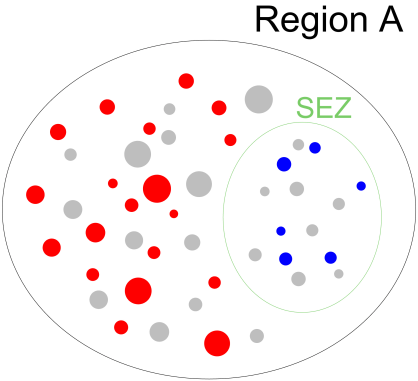


It is $\underbrace{\text{136\% for TFP}}_{\text{selection}}$, $\underbrace{\text{66\% for capital}}_{\text{investment}}$, and $\underbrace{\text{2\% for } cov(z_i, k_i)}_{\text{resource allocation}}$.

Table

Stylized Fact 2: Birth in SEZ performs better



Stylized Fact 2: Birth in SEZ performs better

Indicator	SEZ	Non-SEZ
Avg Productivity (z_i)	2.21	1.03
Avg Capital (k_i)	9.36	8.70
cov (z_i,k_i)	-.002	-.03

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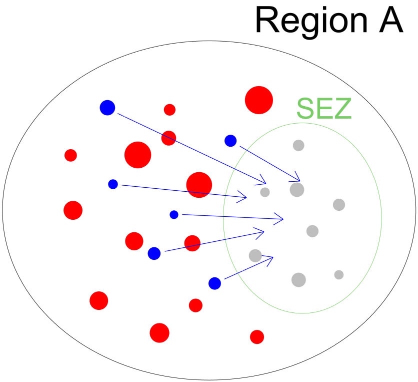
- Average firm TFP in SEZ is 118% larger than in NSEZ.
- Firms born in SEZ capital increase by 66%;
- Average cov(z_i, k_i) in SEZ 2.8% larger than in NSEZ.

Stylized Fact 3: Movers perform better than Stayers



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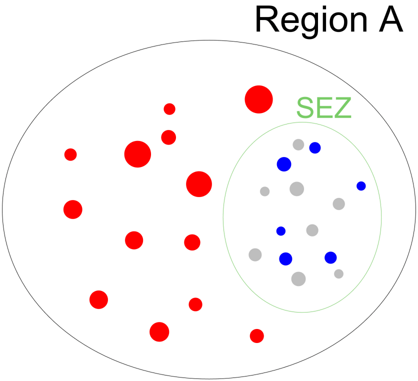

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	Before Move		After Move		Difference			Selection
	SEZ	NSEZ	SEZ	NSEZ	Before Move	After Move	Effect of SEZ	
Avg. Productivity (z_i)	0.84	0.64	1.73	0.95	0.2	0.78	0.58	0.26
Avg. Capital (k_i)	9.02	8.73	9.73	9.16	0.29	0.57	0.28	0.51
cov (z_i, k_i)	-0.04	-0.02	0.07	-0.01	-0.02	0.09	0.10	0.18

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- Better performance in TFP (Avg. Z_i 20% higher)

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Movers have better performance in terms of TFP, capital, resource allocation

Taking stock

- There are significant differences in the performance of firms in SEZ versus NSEZ in terms of (z_i, k_i) and $cov(z_i, k_i)$
- Cannot take those differences as caused by SEZ, because entering in SEZ (through birth or by moving) is endogenous.
- Further, I am after:
  1. Aggregate effects of SEZ
  2. Optimal size of SEZ.

Firm Dynamics Model: Entry, Exit and Location (SEZ) Choice

A Firm Dynamics Model with Entry/Exit/Location

Highlight specific aspects of SEZs $(\tau, \theta, \bar{X})$:

- Corporate tax $\tau^s < \tau^{ns}$
- Financial frictions: borrowing constraint with tightness $\theta^s > \theta^{ns}$
- Minimum profit scale: $\bar{X}$

Economic Environment

- Time is discrete in infinite horizon.
- Two locations in the economy, $l \in \{S, NS\}$ refers to SEZ and NSEZ.
- Heterogeneous firms producing a homogeneous good.
- There is a distribution $\mu_i \equiv \mu(z_i)$ for firm type i.
- Tax revenues are assumed to be rebated lump-sum to consumers.

Firms

1. A continuum of firms;
2. Each firm owns its predetermined capital stock, k and hires labor, l;
3. The production technology is:

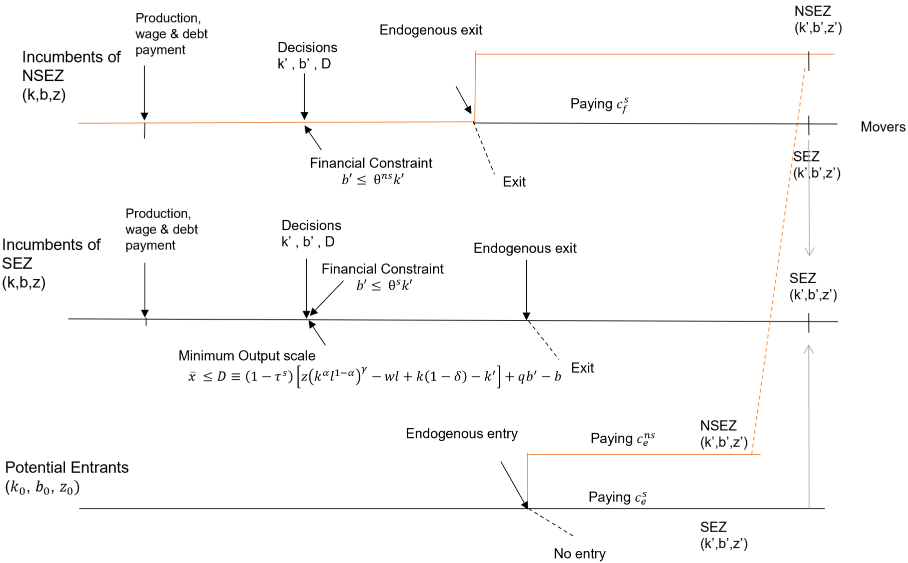
$$y_{it} = z_{it}(k_{it}^{\alpha} l_{it}^{1-\alpha})^{\gamma}$$

   where $0 < \alpha < 1$, $0 < \gamma < 1$
4. Assume that firm productivity z_{it} follows AR(1) process

$$z_{it} = \rho z_{it-1} + \sigma_{\epsilon} \epsilon_{it}$$

5. All debt is priced at q, and firm face a borrowing limit on this one-period discount debt.
6. The borrowing constraint restricts the amount of new debt level, b' not to exceed a firm's collateral, k'.
7. A firm choosing k' in current period, the collateral constraint is $b' \leq \theta^{r} k'$, $r \in \{s, ns\}$, $\theta^{s} > \theta^{ns}$

Timing within a Period



Incumbent firms problem: Location choice

1. Firms profits are:

$$\pi^r(k,b,z) = (1-\tau^r)[z(k^\alpha l^{1-\alpha})^\gamma - wl + k(1-\delta) - k'] + qb' - b$$

where $r \in \{s, ns\}$.

2. Value of a firm indexed by productivity z, capital k and bonds z is

$$V_i^r(k,b,z) = \max_{r\in\{s,ns\}} \{V_i^s(k,b,z), V_i^{ns}(k,b,z)\}$$

$$V_i^r(k,b,z) \quad = \max_{l,b',k'} \ \pi^r(k,b,z) + \beta \mathbb{E}_{z'} \max \left\{ V_i^X(k',b'), V_i^r(k',b',z') - \xi^r \right\}$$

s.t.

$$b' \leq \theta^j k'$$

$$\bar{x}^r \leq D \equiv (1-\tau^r)\left[z(k^\alpha l^{1-\alpha})^\gamma - wl + k(1-\delta) - k'\right] + qb' - b$$

where $\theta^s > \theta^{ns}$, $\bar{x}^{ns} = 0$, $\bar{x}^{ns} > 0$

$$V_x(k',b') = k'(1-\delta) - b'$$

New firms problem: Entry (Birth) and Location Choice

Potential entrants (birth) solve:

$$V_e(k,b,z) \quad = \max \left\{ \underbrace{0}_{\text{No Birth}}, \underbrace{\mathbb{E}_{z'}[V^{ns}(k,b,z)] - c_e^{ns}}_{\text{Birth in NSEZ}}, \underbrace{\mathbb{E}_{z'}[V^{s}(k,b,z)] - c_e^{s}}_{\text{Birth in SEZ}} \right\}$$

That is, firms will invest and start operating iff

$$\mathbb{E}_{z'}[V_e^r(k,b,z)] \geq c_e^r, \quad \text{where} \quad r \in \{s, ns\}$$

Moreover, choosing to enter firms also choose in which location: if

$$V_e^s(k,b,z) - c_e^s \geq V_e^{ns}(k,b,z) - c_e^{ns},$$

then firms choose to enter SEZ (and NSEZ otherwise).

Workers

- A unit measure of identical households in the economy.
- Household earn labor income by supplying labor N, and holds a non-contingent discount bonds ϕ.
- Workers value:

$$V^h(\phi) = \max_{C^h, N^h, \phi'} U(C^h, 1 - N^h) + \beta V^h(\phi')$$

s.t.

$$C^h + q\phi' \leq wN^h + \phi + T$$

where

$$T = \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} \tau^j (y - wl - k' + (1-\delta)k) d\mu^p(k, b, z)$$

Recursive Equilibrium

A stationary competitive equilibrium is composed of an invariant distribution of capital, bonds and productivity $\mu(k, b, z)$; firms' policy functions $l(k, b, z)$, $k(k, b, z)$, $b(k, b, z)$, $j(k, b, z)$; households' policy functions (C^h, N^h, Φ^h); and prices (w, q), such that:

(1) V^{se}, V^{ns} solve firms' problem, and (l, k, b, j) are the associated policy functions for firms.

(2) V^h solve hh problem, and (C^h, N^h, Φ^h) are the associated policy functions for hh.

(3) The labor market clears

$$N^h = \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} l(k, b, z) d\mu^p(k, b, z)$$

Recursive Equilibrium (continued)

(4) Asset market clears

$$\phi^h = \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} b(k,b,z)d\mu^p(k,b,z) - \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} b(k,b,z)d\mu^{ex}(k,b,z)$$

(5) The goods market clears.

$$C^h = \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} \left[z(l^\alpha k^{1-\alpha})^\gamma - (k' - (1-\delta)k) - \xi^j\right] d\mu^p(k,b,z) + \int_{\{(k_0,b_0,z_0)|j(k_0,b_0,z_0)=s,ns\}} (k_0 - c_e^j)d\mu^e(k_0,b_0,z_0) - \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} (1-\delta)kd\mu^{ex}(k,b,z)$$

(6) Resource Constraint

$$T = \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} \tau^j(y - wl - k' + (1-\delta)k)d\mu^p(k,b,z)$$

Recursive Equilibrium (continued)

(7) Distribution follow the law of motion:

$$\mu(k', b', z') = \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} d\mu^{p}(k, b, z)$$
$$+ \int_{\{(k_0,b_0,z_0)|j(k_0,b_0,z_0)=s,ns\}} d\mu^{e}(k_0, b_0, z_0)$$
$$- \int_{\{(k,b,z)|j(k,b,z)=s,ns\}} d\mu^{ex}(k, b, z)$$

Solving the model

- EGM + Upper Envelope theory
- k and b do not separately determine the choices of k' and b'.
- Collapse two state variables into new variable cash-on-hand, $m(k, b, z)$.

$$m(k, b, z) \equiv (1-\tau)\left[z(k^{\alpha}\hat{L}^{(1-\alpha)})^{\gamma} - w\hat{L} + (1-\delta)k\right] - b$$

- $m' \equiv m(k', b', z')$
- Rewrite the incumbent firm's problem in SEZ

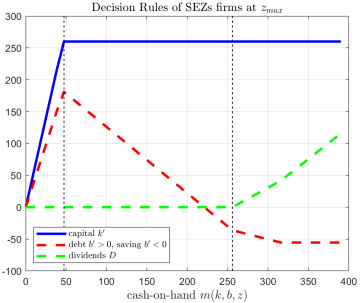
$$V^{s}(m, z) = \max_{k', b', D, m'_j}\left[D + \max\left\{V_x(m), \beta\int_{z'} V(m', z')dG(z'|z)\right\}\right]$$

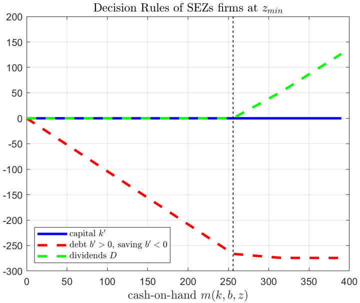
$$\begin{aligned}
s.t.\quad & \bar{X} \leq D \equiv m - k'(1-\tau^{s}) + qb' \\
& b' \leq \theta^{s}k' \\
& m' \equiv m(k', b', z') \\
& = (1-\tau^{s})\left[z'(k'^{\alpha}\hat{L}^{(1-\alpha)}(k', z'))^{\gamma} - w\hat{L}(k', z') + (1-\delta)k'\right] - b'
\end{aligned}$$

Unconstraint l,k | Unconstraint b | Algorithm $\bar{m}$

Firm heterogeneity and Decisions

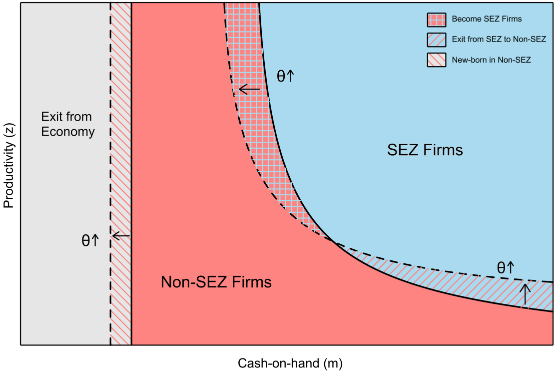
Decision Rules k', b' for firm in SEZs by productivity





- Uncont.firm ($m > \bar{m}$): Unct. k, b; $\pi > 0$
- Const. firm
  1. $\tilde{m} < m < \bar{m}$: zero-profit, accumulate internal financial savings
  2. $m < \tilde{m}$: $b > 0$ up to collateral value k
  3. Firms with low m and z not survive if positively leveraged.

Location choice by wealth and productivity



- Location choice depends on the z_i (y-axis) and m_i (x-axis):
  1. Firms with high z_i and high m_i enter SEZ.
  2. Firms with middle m_i become NSEZ's firms.
  3. Relaxing borrowing const:low m but high z become SEZ.

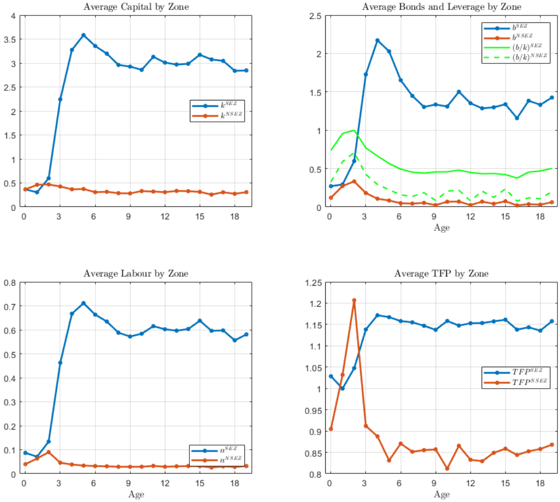
Relaxing Borrowing Constraints

Productivity process and Calibration

- Generate productivity process. z process
- Calibrate parameters both externally and internally (SMM)
- All parameters capture SEZ features are calibrated internally, except τ
- 8 target moments with key moments:
  - SEZ firms' average productivity $>$ NSEZ (empirical evidence).
  - For firms born in SEZ, avg productivity $>$ born in NSEZ.

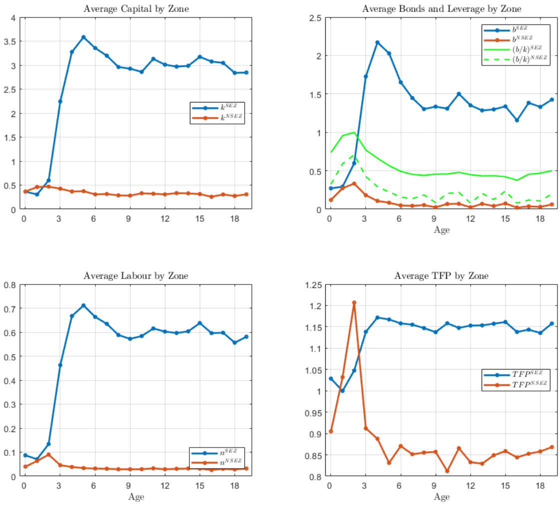
calibration moments

Firm Dynamics (Lifecycle) by Zone



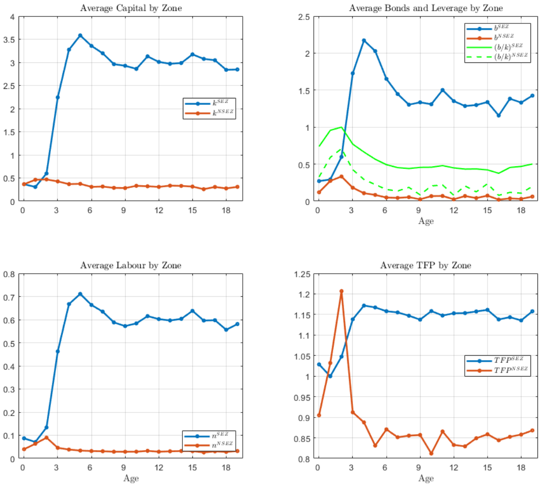
- Avg k (upper-left panel): SEZ firms accumulating capital and become larger than those in NSES.

Firm Dynamics (Lifecycle) by Zone



- Avg b (upper-right panel): SEZ firms more leveraged than those in NSES.

Firm Dynamics (Lifecycle) by Zone



- Avg z (lower-right panel): Age 0, higher z in SEZ.
- Avg z increase in SEZ up to age 4 due to substantial capital accumulation.

Quantitative Experiments

Quant. Experiment: No SEZs Counterfactual

Change SEZ $(\tau, \theta, \bar{X})$ to NSEZ

	Benchmark NSEZs	Benchmark SEZs	Benchmark Overall	No-SEZ Scenario Overall	Effects of SEZs (%)
Aggregate TFP (Z)	.3563	.5271	.5305	.4221	25.70
TFP Distribution:					
Firm-Level TFP (Avg.)	.5262	.6252	.5284	.4221	25.10
Birth Rate	.9736	.8577	.9717	1.00	-2.83
Firm-Level TFP at Birth (Avg.)	.0712	.6397	.4849	.4314	12.40
Death Rate	.0147	.2827	.2974	.2028	46.64
Financial Constraint:					
$cov(z_i, k_i)$ (Avg.)	-.0214	.0346	.0281	-.0249	88.00
Bond-capital ratio (b_i/k_i) (Avg.)	1.0455	.7343	.7456	.5500	35.56
Financial const. firm (%)	.0019	.9997	.0366	.8210	-95.55
Corporate Taxation:					
Effective τ	.0049	.0562	0.18	.0001	1800.31

SEZs improve aggregate TFP by 25.7%:

- Better selection: SEZ $\overline{z_i}$ is 25.1% $>$ NSEZ.
- Less frictioned: Firm TFP more correlated to capital.

After the mechanism: Financial Frictions

No SEZ Counterfactual + (θ^s)

	Benchmark			No-SEZ Scenario	Effects of SEZs
	NSEZs	SEZs	Overall	Overall	(%)
Aggregate TFP (Z)	.3563	.5271	.5305	.4945	7.29
TFP Distribution:					
Firm-Level TFP (Avg.)	.5262	.6252	.5284	.4589	15.14
Birth Rate	.9736	.8577	.9717	.7195	35.06
Firm-Level TFP at Birth (Avg.)	.0712	.6397	.4849	.4314	12.40
Death Rate	.0147	.2827	.2974	.3271	-9.09
Financial Constraint:					
$cov(z_i, k_i)$ (Avg.)	-.0214	.0346	.0281	-.0223	79.36
Bond-capital ratio (b_i/k_i) (Avg.)	1.0455	.7343	.7456	.6616	12.69
Financial const. firm (%)	.0019	.9997	.0366	.5156	-92.91
Corporate Taxation:					
Effective τ	.0049	.0562	.18	.1500	18.75

Less financial frictions in SEZs increase aggregate TFP, 7.29%:

- Better selection: $\overline{z_i}$ in the economy goes up by 15.14%
- Better allocation: Firm TFP more correlated to capital.

After the mechanism: Corporate Taxes

No SEZ Counterfacttal + (τ^s, θ^s)

	Benchmark NSEZs	Benchmark SEZs	Benchmark Overall	No-SEZ Scenario Overall	Effects of SEZs (%)
Aggregate TFP (Z)	.3563	.5271	.5305	.3212	65.15
TFP Distribution:					
Firm-Level TFP (Avg.)	.5262	.6252	.5284	.8389	-37.01
Birth Rate	.9736	.8577	.9717	0.5717	69.66
Firm-Level TFP at Birth (Avg.)	.0712	.6397	.4849	0.0004	108698.04
Death Rate	.0147	.2827	.2974	0.0002	296
Financial Constraint:					
$cov(z_i, k_i)$ (Avg.)	-.0214	.0346	.0281	-.0205	72.95
Bond-capital ratio (b_i/k_i) (Avg.)	1.0455	0.7343	.7456	.6616	24.06
Financial const. firm (%)	.0019	.9997	.0366	.5740	-93.63
Corporate Taxation:					
Effective τ	0.0049	.0562	0.18	.33	-41.01

Less taxes in SEZs increase aggregate TFP, 65.15%:

- Worse selection: $\overline{z_i}$ in the economy goes down by 37.01%
- Better allocation: Firm TFP more correlated to capital.

Summarizing the effects of the SEZs

Aggregate TFP (Z)	benchmark	counterfactual	Difference (%)
Collateral constraint θ	100 (0.5305)	93.2058 (0.4945)	7.29%
+ Corporate income tax τ	100 (0.5305)	60.54 (0.3212)	65.15%
+ Minimal profit scale $\bar{X}$	100 (0.5305)	79.57 (0.4221)	25.7%
Average TFP (z_i)	**benchmark**	**counterfactual**	**Difference (%)**
Collateral constraint θ	100 (0.5284)	93.2058 (0.4589)	15.14%
+ Corporate income tax τ	100 (0.5284)	158.13 (0.8389)	-37.01%
+ Minimal profit scale $\bar{X}$	100 (0.5284)	79.57 (0.4221)	25.1%
$cov(z_i, k_i)$	**benchmark**	**counterfactual**	**Difference (%)**
Collateral constraint θ	100 (0.0281)	-79.36 (-.0223)	79.36%
+ Corporate income tax τ	100 (0.0281)	-72.95 (-.0205)	72.95%
+ Minimal profit scale $\bar{X}$	100 (0.0281)	-88 (-.0249)	88%

Reduced financial frictions:

- Better selection and more efficient resource allocation.

+ Reduced tax:

- Worse selection and less efficient resource allocation (compared to only reduced financial friction).

Conclusion

- SEZ increases aggregate TFP by 25.7%.

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  - Around half of the increase in aggregate TFP due to reduction of financial frictions.

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  - Better selection: average TFP increases by 15.14%.
  - Better resource allocation: $\text{cov}(z_i, k_i)$ increases by 79.36%.

End

Thank you!

Appendix

Stylized Fact 1: Better performance in SEZ

Table: Firm-Level Productivity and Capital Across Zones

Indicator	SEZ	Non-SEZ
Avg Productivity (z_i)	2.21	.85
Avg Capital (k_i)	9.48	8.82
cov (z_i, k_i)	-.00005	-.0239

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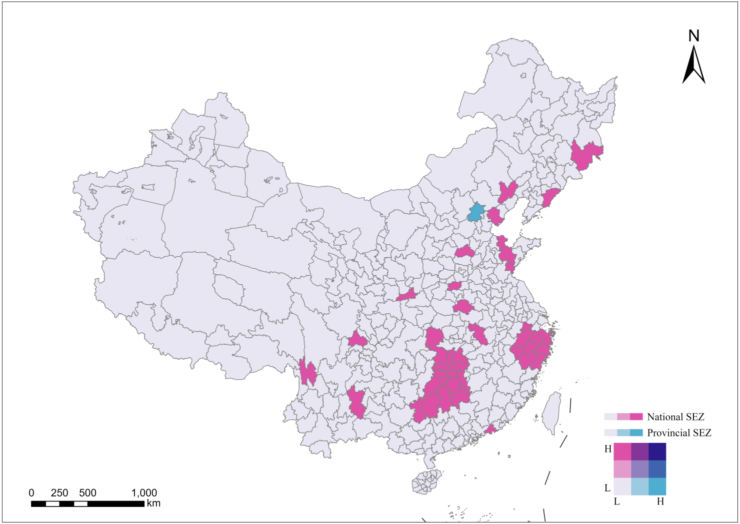
Special Economic Zones (SEZs) in China: Evolution



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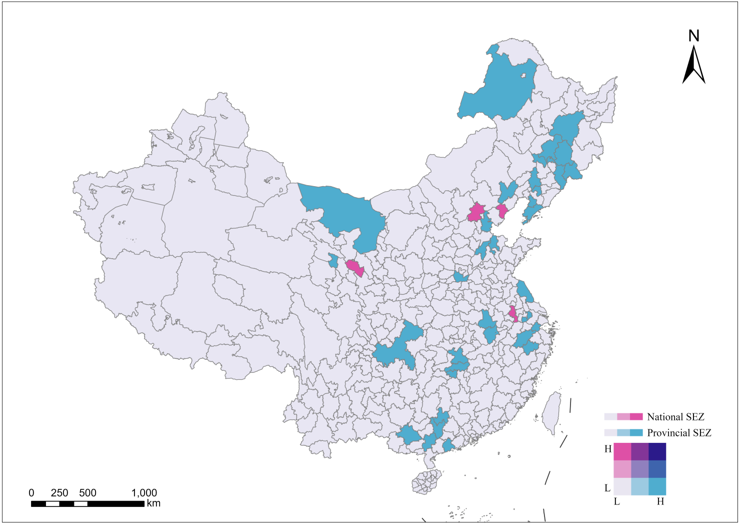
Special Economic Zones (SEZs) in China: Evolution



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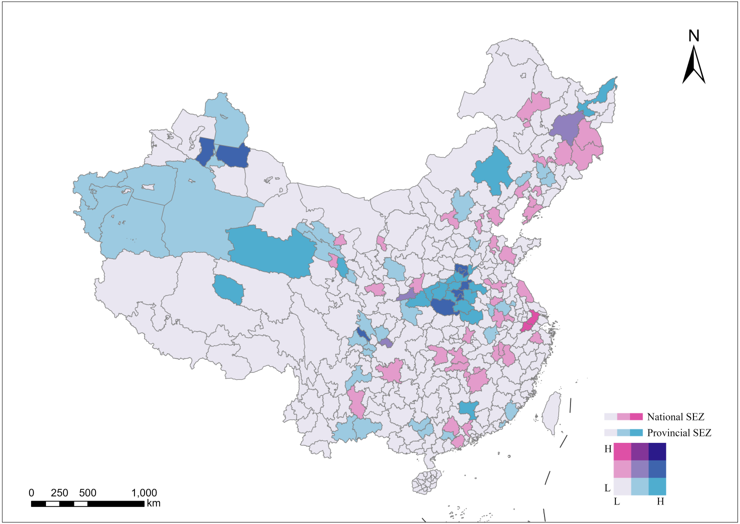

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Data (cont's)

Measurement

- Productivity measurement: TFP is estimated by using Olley&Parks1996:
  Key Variables | OP | TFPResults
- Definition of firms in SEZ: address contains relevance words to SEZs + postal codes + common street/community name
  1.1 Pre-exisiting firm in the SEZ location.
  1.2 Movers into SEZ: firms's address switched from NSEZ to SEZ.
  1.3 New firms in SEZ: borned in SEZ.
- Definition of firms in NSEZ:
  2.1 Not Movers (total): including those firms created in NSEZ after the SEZ is established.
  2.2 New firms in NSEZ created in regions with SEZ
- Time distance: Current year minus year SEZ is established (in district)

Data

Key variables

Key variables need to be used in estimating TFP

1. Value-added: defined as output net of goods purchased for resale, indirect taxes, and material inputs
   1.1 Expenditure Approach (NBS):
   $VA = Output -$ intermediate Input $+$ payable value added tax
   1.2 Income Approach:
   $VA =$ labor compensation [1] $+$ profit $+$ net ind.taxes[2] $+$ dep.
2. Capital stock: total fixed assets value
3. Investment(missing): using the firm's nominal capital stock at original purchase prices as an estimate of nominal fixed investment. Annual investment is $I_t = K_t - K_{t-1} + D_t$. assume depreciation runs at 9% annually.

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[1] labor compensation: salary, unemp. insurance, welfare expenditure, pension contributions(after 2003) + housing subsidy(after 2004)

[2] indirect taxes: sales tax and value added.

Data

Definitions

Productivity is measured by TFP and is estimated by using Olley&Parks1996 to solve simultaneity and selectivity bias:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + f_t^{-1}(k_{it}, i_{it}) + \epsilon_{it}$$

- contribution of capital $\phi_{it} = \beta_k k_{it} + f_t^{-1}(k_{it}, i_{it})$, get estimation $\hat{\phi}_{it}$, then get $\hat{\beta}_l$ from $y_{it} = \beta_l l_{it} + \phi_{it} + \epsilon_{it}$
- Second: set $\omega_{it} = g(\omega_{it-1}) + \xi_{it}$, where $E[\xi_{it}|I_{it-1}] = 0$ get the estimation $\hat{\beta}_k$ from

$$y_{it} - \hat{\beta}_l l_{it} = \beta_k k_{it} + g(\omega_{it-1}) + \xi_{it} + \epsilon_{it}$$

$$= \beta_k k_{it} + g(\hat{\phi}_{it-1} - \beta_k k_{it-1})\xi_{it} + \epsilon_{it}$$

- Thus, with $\hat{\beta}_l$ and $\hat{\beta}_k$ we can get the estimation of TFP, $log\hat{A}_{it}$

back

Data

Definitions

Agglomeration is measured by EG94:

$$\hat{\gamma}_i^{EG} = \frac{\sum_{i=1}^{J}\left(s_{ij}^{c} - s_{*j}\right)^2 - \left(1 - \sum_{j=1}^{J} s_{*j}^2\right)\sum_{k=1}^{K}(z_{k\in i})^2}{\left(1 - \sum_{j=1}^{J} s_{*j}^2\right)\left(1 - \sum_{k=1}^{K}(z_{k\in i})^2\right)}$$

Compute the comprehensive EG Index through the weighted sum for region j for a given year across all the industries

$$\hat{\gamma}_j^{EG} = \sum_{i=1}^{I} \frac{va_{ij}}{va_{i*}} \hat{\gamma}_i^{EG}$$

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Measure TFP

OP and LP

	OP			LP		
	ALL	SEZ	nSEZ	ALL	SEZ	nSEZ
lnK	0.495***	0.404***	0.501***	0.336***	0.301***	0.339***
	(74.61)	(20.80)	(76.34)	(142.22)	(69.12)	(134.21)
lnL	0.589***	0.614***	0.590***	0.350***	0.378***	0.348***
	(206.06)	(71.21)	(214.97)	(186.64)	(183.21)	(234.54)
Observations	255814	27247	228567	1645044	270669	1374375

t statistics in parentheses

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

Staggered DID

Event study (common trend test)

The dynamic effects of the establishment of SEZ are based on:

$$TFP_{it} = \theta_i + \alpha_t + \gamma_r + \beta_0 D_{iT} + \sum_{m=1}^{M} D_{i,t-T=-m}\beta_{-m} + \sum_{s=1}^{S} D_{i,t-T=s}\beta_s + \epsilon_{it} \quad (1)$$

where

- $D_{i,t-T} = 1$, if a SEZ firm is m years prior to entering SEZs and β_{-m} represents the impact of SEZ on TFP;
- $D_{i,t-T=s} = 1$, if firm in SEZ after s years and β_s identifies the effect of the SEZ s years following its entrance.

Vars definitions estimates

Staggered DID

(Baseline specification)

To identify the effects of SEZ on firms' TFP, I setup a DID with staggered adoption capturing time variation of SEZ experiment across firms.

Here, I focus on two groups: Pre-SEZ firms in the SEZ (treatment) and pre-SEZ firms in the NSEZ (control)

Specification:

$$TFP_{it} = \theta_i + \alpha_r + \gamma_t + \beta D_{it-T} + \delta X_{it} + \epsilon_{it} \tag{2}$$

$D_{i,t-T} = treat_i \times post_{i,t-T}$, treatment indicator that is equal to one in the years after firm i entered in the SEZ and zero otherwise. I am interested in the impact of SEZ on the productivity: β.

Panel Firm-Level Data

[I1] Treatment: Pre-SEZ firms in SEZ (0.5%). Control: Pre-SEZ firms in NSEZ.

Panel Firm-Level Data

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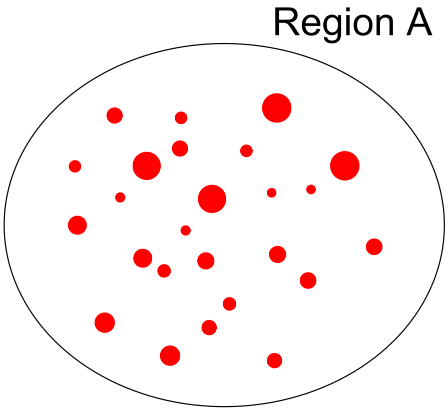
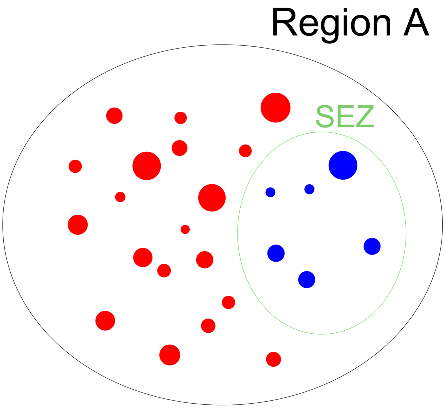


Change layers: First layer has all dots gray, second layer adds the SEZ green circumference, third layer adds the blue and red colors.

Panel Firm-Level Data

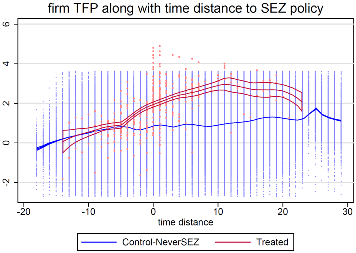
[I1] Treatment: Pre-SEZ firms in SEZ (0.5%). Control: Pre-SEZ firms in NSEZ.



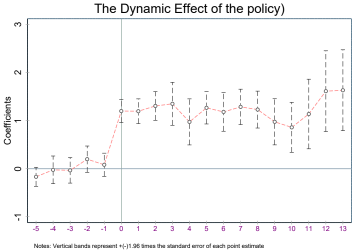
Panel Firm-Level Data

[I1] Treatment: Pre-SEZ firms in SEZ (0.5%). **Control: Pre-SEZ firms in NSEZ.**

(a) Raw Data (normalized at SEZ_0)



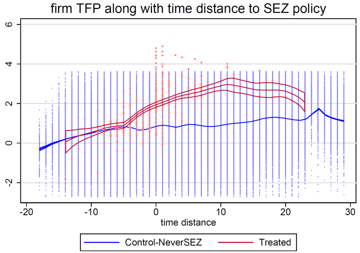
(b) Staggered DID



Panel Firm-Level Data

[I1] Treatment: Pre-SEZ firms in SEZ (0.5%). Control: Pre-SEZ firms in NSEZ.

(a) Raw Data (normalized at SEZ_0)



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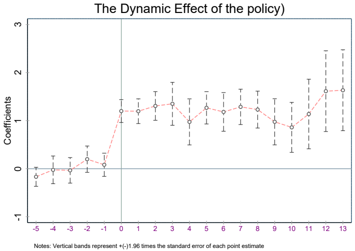

But the the policy (where SEZs are set up) is endogenous. Plus the share of pre-SEZ firms in SEZ is small...

Few things that apply to the three identification strategies: (1) x-axis in these figures need to be changed to SEZ age; (2) remove the dots in panel (a) and keep only the lpolys (or whatever polynomial you are using; (3) in the panel (a) of this I1 (and also I3) keep the range of the horizontal axis from -10 to 20; (4) In panel (a) here and the slides to follow with the other identification strategies, interchange blue (treatment) and red (control); (5) In panel (a) Add vertical line at zero; (6) make numbers bigger in all axis; (7) Remove the title from the graph.

Agglomeration Effect

A mediation effect model to test the impact mechanism of the agglomeration effect

$$EG_{jrt} = \alpha_{rt} + \theta_j + \gamma D_{it} + \epsilon_{jrt} \quad (3)$$

$$TFP_{it} = \theta_i + \alpha_{rt} + \beta_1 D_{it} + \beta_2 EG_{jrt} + \delta X_{it} + \epsilon_{it} \quad (4)$$

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Mediation Effect through Agglomeration on TFP

	(OLS)	(SepFE)	(corssFE)
Model with TFP regressed on SEZ (path c)			
SEZ	1.222 ***	0.909***	0.922***
	(775.16)	(316.53)	(321.20)
constant	.857***	0.912***	0.909***
	(1241.31)	(1367.41)	(1374.28)
Observations	2310570	2319020	2318971
R-sq	0.206	0.766	0.777
Model with mediator ***EG_irt*** **regressed on SEZ (path a)**			
SEZ	.002 ***	0.00000453	-0.0000282*
	(187.78)	(0.30)	(-1.86)
constant	.007***	0.00762***	0.00763***
	(1265.86)	(2175.36)	(2172.91)
Observations	2310570	2331564	2331508
R-sq	0.0150	0.881	0.884
Model with TFP regressed on mediator ***EG_irt*** **and SEZ (paths b and c')**			
Agglomeration	19.24***	6.502***	5.686***
	(242.25)	(45.73)	(40.33)
SEZ	1.176***	0.907***	0.920***
	(749.32)	(315.19)	(319.98)
constant	0.720***	0.868***	0.872***
	(810.88)	(681.96)	(690.01)
Observations	2310570	2294206	2294152
R-sq	0.226	0.766	0.777

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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Sobel Test: indirect effect

In addition, a sobel test permits us to determine whether the mediation agglomeration effect plays a role in how SEZs influence productivity.

Sobel-Goodman Mediation Tests

	Coef	StdErr	Z	P>Z
Sobel	0.047	0.0003	148.4	0
Goodman-1	0.047	0.0003	148.4	0
Goodman-2	0.047	0.0003	148.4	0
	Coef	StdErr	Z	P>Z
η	0.002	0.000013	187.78	0
β_2	19.24	0.079	242.25	0
Indirect effect	0.047	0.000314	148.412	0
Direct effect	1.176	0.0016	749.32	0
Total effect	1.222	0.0016	775.159	0

Proportion of total effect that is mediated: 0.0381
Ratio of indirect to direct effect: 0.0396
Ratio of total to direct effect: 1.039

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- How do firms get access to SEZs? Comprehensive evaluation system for firms: According to type of projects, investment scale, investment intensity, output efficiency, scientific and technological content

- Who chooses SEZs? Decentralized: The city govern. $\rightarrow$ provincial govern. $\rightarrow$ Central government. How SEZ is chosen? Economic development, technology innovation, Energy consumption, environmental protection, Social Insurance coverage. (Provencial-level SEZ $\rightarrow$ National-level SEZ: if Annual industrial output, tax revenue, export, FDI $>$ certain amount)

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Share of number of firms in different cases

Type	Share
Treated Firm	0.07
Movers SEZ	5.81
Movers (Pre-SEZ)	0.95
Movers (After-SEZ)	4.85
New in SEZ	7.25
SEZ	13.12
Not Movers (Pre-SEZ)	29.8
New in NSEZ	39.87
New in No SEZ	16.62
Out of SEZ	86.3
Observations	82,290

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Staggered DID (Total Sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10	m11	m12
SEZ	0.909***	0.898***	0.973***	0.972***	0.978***	0.957***	0.922***	0.905***	0.974***	0.974***	0.966***	0.959***
	(199.94)	(146.89)	(157.50)	(157.33)	(116.02)	(205.65)	(205.54)	(149.22)	(159.00)	(158.85)	(116.45)	(207.01)
size		0.127***	0.109***	0.109***				0.117***	0.0995***	0.0992***		
		(53.62)	(39.96)	(39.62)				(48.92)	(35.93)	(35.69)		
lnage		-0.0569***	-0.0310***	-0.0307***	-0.0509***	-0.0277***		-0.0508***	-0.0209***	-0.0208***	-0.0486***	-0.0207***
		(-25.32)	(-12.02)	(-11.83)	(-12.26)	(-15.98)		(-23.07)	(-8.30)	(-8.19)	(-11.97)	(-12.19)
lnROA		0.0695***	0.0144***	0.0145***				0.0645***	0.0129***	0.0129***		
		(125.15)	(26.37)	(26.34)				(118.92)	(23.74)	(23.74)		
ln(Debt ratio)		-0.0454***	-0.0342***	-0.0341***	-0.0217***	-0.0215***		-0.0374***	-0.0331***	-0.0329***	-0.0213***	-0.0204***
		(-22.59)	(-14.66)	(-14.60)	(-10.61)	(-14.94)		(-19.12)	(-14.40)	(-14.30)	(-10.51)	(-14.41)
Export		-0.00881***						0.000799				
		(-3.07)						(0.27)				
State-owned		-0.0700***	-0.0331***	-0.0331***	-0.00470	-0.0281***		-0.0586***	-0.0193**	-0.0198**	-0.00206	-0.0153***
		(-9.69)	(-3.96)	(-3.95)	(-0.40)	(-4.93)		(-8.19)	(-2.29)	(-2.34)	(-0.17)	(-2.72)
lnky			-0.721***	-0.720***	-0.623***	-0.621***			-0.718***	-0.718***	-0.625***	-0.623***
			(-341.86)	(-340.89)	(-255.78)	(-379.93)			(-338.14)	(-337.20)	(-256.90)	(-379.20)
ln(Export density)			-0.00644***	-0.00658***	-0.00674***	-0.00803***			-0.00621***	-0.00628***	-0.00678***	-0.00766***
			(-4.90)	(-4.98)	(-5.27)	(-8.86)			(-4.78)	(-4.81)	(-5.40)	(-8.56)
lnEG				0.00819**	0.00406	0.00700***				0.00775**	0.00611	0.00687***
				(2.41)	(1.08)	(3.14)				(2.29)	(1.62)	(3.10)
lnsales					0.0936***						0.0855***	
					(31.02)						(27.83)	
lnprofit_net					0.0618***	0.0648***					0.0604***	0.0618***
					(61.35)	(95.48)					(60.71)	(92.47)
lnY						0.0437***						0.0353***
						(22.77)						(18.48)
_cons	0.912***	-0.103***	0.0305	0.0744**	-0.174***	0.275***	0.909***	-0.0114	0.111***	0.151***	-0.0640*	0.372***
	(1050.59)	(-4.26)	(1.05)	(2.14)	(-4.56)	(11.59)	(1062.27)	(-0.47)	(3.76)	(4.35)	(-1.65)	(15.75)
Observations	2319020	777655	205890	205053	251997	413465	2318971	777497	205374	204540	251730	412935
R-sq	0.766	0.820	0.949	0.949	0.944	0.945	0.777	0.830	0.952	0.952	0.947	0.948

t statistics in parentheses

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

Heterogeneous SEZ effects

	(1) quantile20%	(2) 40%	(3) 60%	(4) 80%	(5) 100%
Pre1					
SEZ	1.415***	1.035***	0.905***	0.761***	0.487***
	(108.03)	(95.69)	(80.06)	(62.24)	(34.15)
constant	0.127***	0.809***	1.133***	1.468***	2.153***
	(12.03)	(92.62)	(125.78)	(152.22)	(193.97)
Observations	29178	28886	27235	25973	24360
R-sq	0.742	0.688	0.655	0.614	0.596
Pre2					
SEZ	1.275***	1.012***	0.910***	0.779***	0.583***
	(77.03)	(70.04)	(63.41)	(52.58)	(33.71)
constant	0.257***	0.795***	1.093***	1.430***	1.995***
	(23.13)	(83.01)	(116.61)	(151.27)	(185.39)
Observations	24079	24026	23496	22498	21489
R-sq	0.751	0.722	0.680	0.639	0.590
Pre3					
SEZ	1.176***	0.998***	0.918***	0.786***	0.692***
	(61.88)	(55.15)	(51.82)	(39.76)	(30.99)
constant	0.344***	0.806***	1.102***	1.420***	1.920***
	(31.22)	(78.18)	(111.24)	(130.46)	(158.05)
Observations	22272	21648	20876	19305	17981
R-sq	0.752	0.731	0.700	0.641	0.611
Pre4					
SEZ	1.068***	0.942***	0.929***	0.832***	0.817***
	(44.49)	(42.05)	(38.20)	(31.54)	(28.76)

Mechanism study

Agglomeration effect

- Mediation model: test whether the SEZ affects the productivity through the agglomeration effect.
- Decompose total policy effect into: Indirect (Agglomeration) effect and direct (policy) effect.

$$EG_{jrt} = \theta_j + \alpha_r + \gamma_t + \eta D_{it} + \epsilon_{jrt} \quad (5)$$

$$TFP_{it} = \theta_i + \alpha_r + \gamma_t + \beta_1 D_{it} + \beta_2 EG_{jrt} + \delta X_{it} + \epsilon_{it} \quad (6)$$

back Sobeltest

Mediation effect through Agglomeration on TFP

	(OLS)	(SepFE)	(corssFE)
Model with TFP regressed on SEZ (path c)			
SEZ	1.222 ***	0.909***	0.922***
	(775.16)	(316.53)	(321.20)
constant	.857***	0.912***	0.909***
	(1241.31)	(1367.41)	(1374.28)
Observations	2310570	2319020	2318971
R-sq	0.206	0.766	0.777
Model with mediator *EG_irt* regressed on SEZ (path a)			
SEZ	.002 ***	0.00000453	-0.0000282*
	(187.78)	(0.30)	(-1.86)
constant	.007***	0.00762***	0.00763***
	(1265.86)	(2175.36)	(2172.91)
Observations	2310570	2331564	2331508
R-sq	0.0150	0.881	0.884
Model with TFP regressed on mediator *EG_irt* and SEZ (paths b and c')			
Agglomeration	19.24***	6.502***	5.686***
	(242.25)	(45.73)	(40.33)
SEZ	1.176***	0.907***	0.920***
	(749.32)	(315.19)	(319.98)
constant	0.720***	0.868***	0.872***
	(810.88)	(681.96)	(690.01)
Observations	2310570	2294206	2294152
R-sq	0.226	0.766	0.777

t statistics in parentheses

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

▸▸ Agglomeration Effect

Mediation effect through Agglomeration on TFP

Sobel test

Sobel-Goodman Mediation Tests

	Coef	StdErr	Z	P>Z
Sobel	0.047	0.0003	148.4	0
Goodman-1	0.047	0.0003	148.4	0
Goodman-2	0.047	0.0003	148.4	0

	Coef	StdErr	Z	P>Z
η	0.002	0.000013	187.78	0
β_2	19.24	0.079	242.25	0
Indirect effect	0.047	0.000314	148.412	0
Direct effect	1.176	0.0016	749.32	0
Total effect	1.222	0.0016	775.159	0

Proportion of total effect that is mediated: 0.0381
Ratio of indirect to direct effect: 0.0396
Ratio of total to direct effect: 1.039

Agglomeration Effect

Mediation effect through Agglomeration on TFP

Sobel test across sub-samples

Sobel-Goodman Mediation Tests

	Botton 20%	40%	60%	80%	100%
Sobel	.041 ***	.0174 ***	.0111 ***	.0098 ***	.0066 ***
	(16.95)	(10.88)	(6.97)	(7.29)	(5.024)
Goodman-1	.041 ***	.0174 ***	.0111 ***	.0098 ***	.0066 ***
	(16.94)	(10.87)	(6.96)	(7.28)	(5.00)
Goodman-2	.041 ***	.0174 ***	.0111 ***	.0098 ***	.0066 ***
	(16.96)	(10.89)	(6.98)	(7.31)	(5.04)
η	.0029 ***	0.0022 ***	.0025 ***	.00196 ***	0.0018 ***
	(29.04)	(19.13)	(20.19)	(13.46)	(9.59)
β_2	14.11 ***	7.88 ***	4.421 ***	5.014 ***	3.57 ***
	(20.87)	(13.22)	(7.43)	(8.68)	(5.90)
Indirect effect	0.041 ***	.0174 ***	.0111 ***	.0098 ***	.0066 ***
	(16.95)	(10.88)	(6.97)	(7.29)	(5.024)
Direct effect	1.762 ***	1.456 ***	1.274 ***	1.068 ***	.638 ***
	(159.94)	(149.323)	(129.89)	(102.35)	(47.43)
Total effect	1.803 ***	1.473 ***	1.286 ***	1.078 ***	.645 ***
	(164.887)	(151.83)	(132.37)	(103.65)	(48.02)
Proportion of total effect that is mediated:	.0226	.0117	.0086	.0091	.0101
Ratio of indirect to direct effect:	.0231	.0119	.0087	.0092	.0103
Ratio of total to direct effect:	1.023	1.012	1.008	1.009	1.010

Robustness check sobeltestFE

Unconstrained

Labor and Capital Decision Rules

Unconstrained firm, it never experiences binding borrowing constraints in any possible future state

- Optimal static labor choice. A firm with (k, z) chooses
  $\hat{L}(k,z) = \left[\frac{(1-\tau)*(zk^{\alpha\gamma}(1-\alpha)\gamma)}{w}\right]^{\frac{1}{1-(1-\alpha)\gamma}}$
- Current earnings with optimal labor hiring $\hat{l}$, then
  $\hat{\Pi} = (1-\tau)\left[z(k^{\alpha}\hat{L}^{(1-\alpha)})^{\gamma} - w\hat{L}\right]$
- Choice of future capital, k' by the unconstrained firms (collateral constraint is not binding), optimal level of $k' = \hat{K}(z)$, which is the solution of the following problem.

$$\max_{k'}\left[-(1-\tau)k' + \beta\sum_{j=1}^{N_z}\pi_{ij}^{z}\left(\hat{\Pi}(k',z_j) + (1-\tau)(1-\delta)k'\right)\right]$$

back

Unconstrained
Debt Decision Rules

- With policy functions $\hat{L}, \hat{K}$, the optimal debt policy $b' = \hat{B}(z)$ is defined by the following equations.

$$\hat{B}(z_i) = \min\left(\tilde{B}\left(\hat{K}(z_i), z_j\right)\right)$$

where $\tilde{B}\left(\hat{K}(z_i), z_j\right)$ is the maximum level of debt that an unconstrained firm can hold in which $z' = z_j$ is realized.

- Maximum level of debt of the unconstrained firm unaffected by the constraint over any future path of z.

$$\tilde{B}(k, z_i) + \bar{x} = (1-\tau)\left[z_i\left(k^{\alpha}\hat{L}^{1-\alpha}\right)^{\gamma} - w\hat{L} + (1-\delta)k - \hat{K}(z_i)\right] + q\min\left\{\hat{B}(z_i), \theta\hat{K}(z_i)\right\}$$

back

Cash-on-hand

- The incumbent firm's problem is a challenging because of the occasionally binding constraints for b' and D.
- k and b do not separately determine the choices of k' and b'.
- Collapse two state variables into new variable cash-on-hand, $m(k, b, z)$.

$$m(k,b,z) \equiv (1-\tau)\left[z(k^{\alpha}\hat{L}^{(1-\alpha)})^{\gamma} - w\hat{L} + (1-\delta)k\right] - b$$

- $m' \equiv m(k', b', z')$
- Rewrite the incumbent firm's problem in SEZ

$$V^s(m,z) = \max_{k',b',D,m'_j}\left[D + \max\left\{V_x(m), \beta\int_{z'} V(m',z')dG(z'|z)\right\}\right]$$

$$\begin{aligned} s.t.\ \ \bar{X} &\leq D \equiv m - k'(1-\tau^s) + qb' \\ b' &\leq \theta^s k' \\ m' &\equiv m(k',b',z') \\ &= (1-\tau^s)\left[z'(k'^{\alpha}\hat{L}^{(1-\alpha)}(k',z'))^{\gamma} - w\hat{L}(k',z') + (1-\delta)k'\right] - b' \end{aligned}$$

back

Cash-on-hand and decision rules

$\tilde{m}$ and $\bar{k}$

- Three cases:
  1. D Not binding + Financial Constraint Not binding:
  $$\hat{D} = m - \hat{K}(1-\tau^s) + q\hat{B} > \bar{X}$$
  2. D binding + Financial Constraint Not binding ($m < \tilde{m}(z)$ & $\hat{K} \leq \bar{K}$)
  $$\tilde{m}(z) = \hat{K}(z)(1-\tau^s) - q\hat{B} + \bar{X}$$
  $$b' = \frac{1}{q}\left(\hat{K}(z)(1-\tau^s) + \bar{X} - \tilde{m}\right)$$
  3. D binding + Financial Constraint binding ($\hat{K} > \bar{K}$)
  $$\bar{K} = \frac{\tilde{m} - \bar{X}}{(1-\tau^s) - q\theta}$$

back

Productivity process

1. $z_{it} = A_i v_{it}$, transitory component follows Pareto distribution with shape parameter μ,

$$Pr(A_i \leq a) = 1 - a^{-\mu}$$

2. Idiosyncratic component v follows AR(1) process:

$$log(v_{it}) = \rho log(v_{it-1}) + \sigma \epsilon_{it}$$

3. Target, distribution of value added: target the fractions of value added in the top 5 (distribution is skewed in the top 5 percentile of firms accounts for about 34% of the total value added);
4. Autocorrelation of value added: 0.796
5. Standard deviation of va growth rate: 0.0077

back

Calibration: externally and internally (SMM)

Parameter		Value
Corporate income tax rate NSEZ	τ^{ns}	0.33
Corporate income tax rate SEZ	τ^{s}	0.195
Discount factor	β	0.961
Capital Share	α	0.37
Depreciation rate	δ	0.068
Span of control	γ	0.862
Shock standard deviation	σ	0.0077
Shock persistence	ρ	0.7968
Pareto shape parameter	μ	8.6955

Internally Calibrated Parameters			
Parameter		Value	
		SEZs	NSEZs
Collateral Constraint	θ_i	0.88	0.62
Fixed Operating cost	ξ_s	0.01	0.034
Minimal profit scale	$\bar{x}_s$	0.003	0
Entering cost	c_i^e	0.0083	0.0081

The internally calibrated parameters are the result of simulated methods of moments (SMM). back

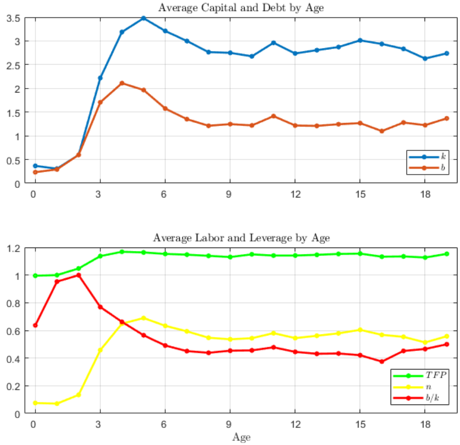
Model Fit

Moments				
Target Moments	Data		Model	
I/Y	.0847		3.2709	
wL/Y	.7012		.4585	
$AvgTFP^{sez} / AvgTFP^{nsez}$	2.4715		1.188	
$AvgTFP_0^{sez} / AvgTFP_0^{nsez}$	2.5305		8.98	
Exit rate from SEZ	.10		.2827	
New business (%)				
Relative B_0 to Incumb	.1827		.3034	
	NSEZ		SEZ	
	Data	Model	Data	Model
Average leverage (debt/capital)	.9590	0.7343	.9622	1.046

- Avg productivity SEZ firms 2.4 times greater than NSEZ
- Avg productivity for firms born in SEZ 2.5 larger than NSEZ
- Avg debt-to-capital ratio higher in SEZ

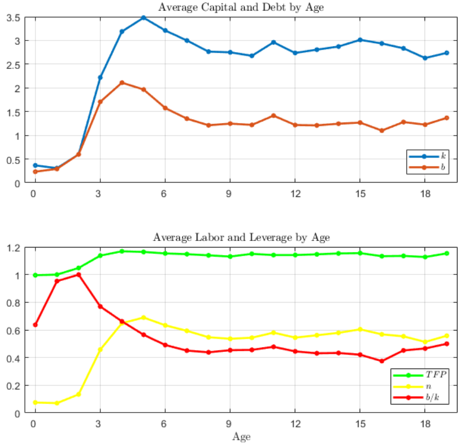
back

Firm Dynamics (Lifecycle)



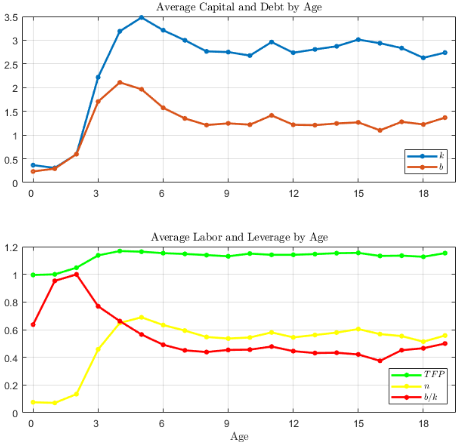
- Avg k dynamics by age (upper panel):
  1. Young firms start small at birth
  2. Age 0, firm face financial const. due to limited k.

Firm Dynamics (Lifecycle)



- Avg b dynamics by age (upper panel):
  1. Young firms have largest borrowing levels at beginning and de-leverage over time, conditional on survival.
  2. Firm after 6 adopt unconstrained k (high leverage before 6).

Firm Dynamics (Lifecycle)



- Avg z dynamics by age (lower panel):
  1. As older, selection forces unproductive firms to exit.
  2. Average z increases up to age-4, z of age-0 firms is around 20% lower than that of age-20 firms.

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