Land Offers and Fiscal Competition Between City Governments in China
(Thesis Proposal Review)

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Motivation

- China's governance structure is unusual in combining a high degree of political centralization and economic decentralization. (Kroeber, 2020; Xu, 2011)
- One of the most salient characteristics of the system is the competition among city governments which use special deals to attract businesses. (Bai, Hsieh, & Song, 2020)
- A major type of special deals is selling industrial lands at low price to firms. (Su & Tao, 2017)
- Why local governments in China compete against each other to attract industrial firms so fiercely that they are willing to sacrifice the industrial land selling revenue ?
- What and how much are the benefits city governments can get from this kind of fiscal competition?
- Can this kind of fiscal competition improve the allocation efficiency or does it lead to "race to bottom"?
- Can this kind of fiscal competition continue in future?

Motivation

An industrial park in the author's hometown

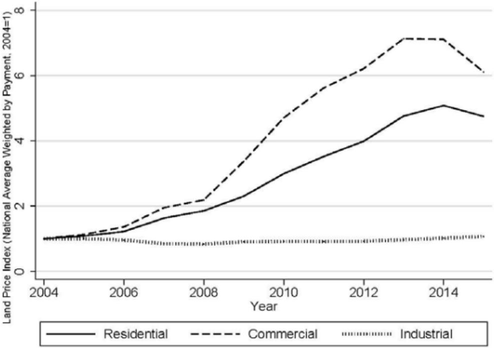
Work program of a vice-mayor (who takes charge of education!) in China (Bai et al., 2020)

Literature Review

- Fiscal Competition Theory
  - Tiebout Model: competition for mobile capitals creates efficient equilibrium (Tiebout, 1956).
  - Tax competition Model: downward pressure on fiscal revenues from the decentralization of fiscal power (Keen & Marchand, 1997).
  - The possibilities of a "race to bottom" in welfare benefits due to "fiscal externality" (Wilson, 1999).
- Fiscal Competition with Chinese characteristics
  - Studies observe that local governments use discounts in land sale as a main tool to attract businesses include Cheung (2014), Su and Tao (2017), Bai et al. (2020), etc.
  - No formal theoretical model and econometric analysis yet.
- Empirical Analysis
  - Mast (2020) uses structural estimation to analyze the county tax break for small business in U.S.

Fiscal Competition and Land Market in China

- City governments (293 prefecture-level cities + 4 municipalities) control the land supply.
- Land revenue represented 30% of the total government revenue and 6% of total GDP by 2011 (Chen & Kung, 2019).
- But interestingly, the price of industrial land is significantly lower than the price of residential land.

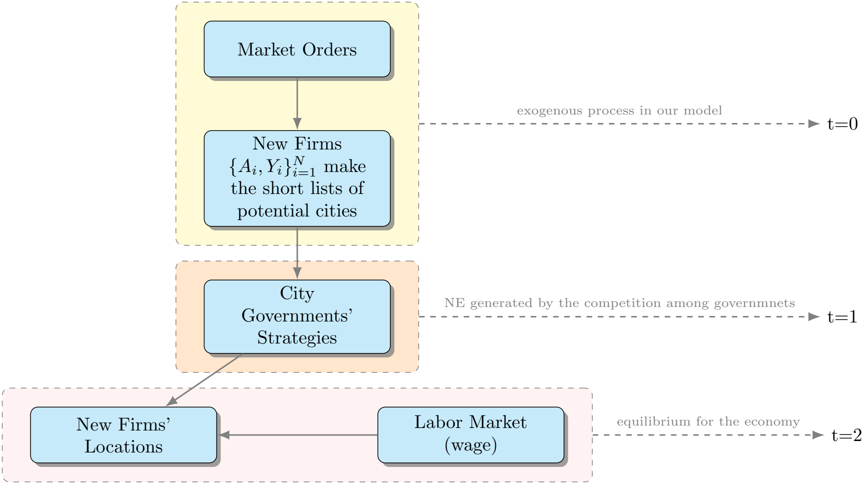


Land price index in China (Source: Liu and Xiong (2020))

Fiscal Competition and Land Market in China

- The reason behind the seemingly confusing phenomenon is deeply rooted in the fiscal structure of Chinese local governments.
- After the tax reform in 1993-1994, the main source of local government's fiscal revenue come from 25% of value added tax, business tax, and 40% of income tax plus the land lease fees.
- To maximize the fiscal revenue, local governments use special deals to attract industrial firms. And a major type of special deals is to sell industrial lands at very low price to firms.
- Why industrial firms are so important for local governments?
  - more (industrial) firms $\rightarrow$ more workers $\rightarrow$ prosperity of the tertiary industry $\rightarrow$ increasing housing demand and tax revenue.
  - City governments can maximize their revenues by limiting residential land supply given the increasing housing demand.
- This paper focuses on the fiscal competition, i.e. attracting firms by lowering the land price, as well as its impact on fiscal revenue.

Main structure of the model (solid arrows represent causal channels)



Firms

- Firm i's (Leontief) production function:
$$F_i(K, L, T) = \min\{A_i K^{\alpha} L^{1-\alpha}, g_i(T)\}$$
where T is the area of industrial land, which determines the limit of output. $g_i(T)$ is increasing in T.
- New firm i signs a contract to produce Y_i units of product with buyers on the global market. The price of product is normalized to 1 RMB.
- Firm i solves the following cost minimization problem:
$$\begin{aligned} &\min_{k \in \mathbf{C}_i, K_i, L_i, T_i} \left\{ rK_i + w_k L_i + \frac{p_{ik}}{m} T_i - \varepsilon_{ik} \right\} \\ &\text{s.t. } Y_i = \min\left\{ A_i K_i^{\alpha} L_i^{1-\alpha}, g_i\left(T_i\right) \right\} \end{aligned} \tag{1}$$
  - p_{ik}: land price for firm i offered by city k.
  - m: term (years) of land lease.
  - $\mathbf{C}_i$: firm i's choice set. $|\mathbf{C}_i|$ is nondecreasing in Y_i.
  - ε_{ik}: error term represents all other unobserved costs and benefits for firm i to produce in city k. We assume ε_{ik} has type I extreme value distribution with scale parameter σ.

Firms

- We fix k in (1), and the solution to cost minimization problem for firm i to produce in city k is:

$$
\begin{aligned}
\text{Labors:} \quad & L_i = \Big(\frac{1-\alpha}{\alpha}\Big)^{\alpha}\Big(\frac{r}{w_k}\Big)^{\alpha}\frac{Y_i}{A_i} = B_i w_k^{-\alpha} \\
\text{Capital:} \quad & K_i = \frac{\alpha}{1-\alpha}\cdot\frac{w_k}{r}\cdot L_i = \frac{\alpha}{r(1-\alpha)}B_i w_k^{1-\alpha} \\
\text{Land:} \quad & T_i = g_i^{-1}(Y_i)
\end{aligned} \tag{2}
$$

  where $B_i := \left(\frac{(1-\alpha)r}{\alpha}\right)^{\alpha}\frac{Y_i}{A_i} = L_i w_k^{\alpha}$ only depends on characteristics of firm i.

- The minimal cost of producing in city k for firm i:

$$
\begin{aligned}
c_{ik} &= w_k\cdot L_i + r\cdot K_i + \frac{p_{ik}}{m}\cdot T_i - \varepsilon_{ik} \\
&= \frac{1}{1-\alpha}B_i w_k^{1-\alpha} + \frac{p_{ik}}{m}T_i - \varepsilon_{ik}
\end{aligned} \tag{3}
$$

Firms

- After knowing c_{ik} for all $k \in \mathbf{C}_i$, the firm i just chooses the city k which has the minimal production cost:

$$k^* = \arg\min_{k \in \mathbf{C}_i} c_{ik}$$

- Since the distribution of ε_{ik} is common knowledge among all city governments in the choice set, city governments in $\mathbf{C}_i$ can calculate the probability of landing firm i successfully in their geographical jurisdiction:

$$\begin{aligned} Pr(\text{i lands in k}|p_{ik}, p_{i(-k)}) &= Pr(c_{ik} < c_{ij} \ \forall j \in \mathbf{C}_i \setminus k) \\ &= \frac{exp\left[(-\frac{1}{1-\alpha} B_i w_k^{1-\alpha} - \frac{p_{ik}}{m} T_i)/\sigma\right]}{\sum_{j \in \mathbf{C}_i} exp\left[(-\frac{1}{1-\alpha} B_i w_j^{1-\alpha} - \frac{p_{ij}}{m} T_i)/\sigma\right]} \end{aligned} \tag{4}$$

City Governments

- The city government's revenue gotten from attracting new firms:
  - the fiscal revenue generated by the new firm itself, which includes tax revenue, promotion of local business and housing market, corruption, political benefits, etc.
  - the fiscal revenue generated by selling the industrial land.
- We denote the expected fiscal revenue for city k to attract firm i by v_{ik}:

$$\begin{aligned} v_{ik} &= Pr(i \text{ lands in } k | p_{ik}, p_{i(-k)}) \cdot (\beta Y_i + p_{ik} T_i) \\ &= \frac{exp\left[\left(-\frac{1}{1-\alpha} B_i w_k^{1-\alpha} - \frac{p_{ik}}{m} T_i\right)/\sigma\right]}{\sum_{j \in \mathbf{C}_i} exp\left[\left(-\frac{1}{1-\alpha} B_i w_j^{1-\alpha} - \frac{p_{ij}}{m} T_i\right)/\sigma\right]} \cdot (\beta Y_i + p_{ik} T_i) \end{aligned} \tag{5}$$

- βY_i is the fiscal revenue generated by the new firm itself, and $\beta \geq 0$ can be interpreted as the revenue share of city governments in the output of the firm.
- $p_{ik} T_i$ is just the land selling revenue.
- Trade-off between higher land selling revenue and higher probability of getting the firm.

Bertrand Game

- When a city government chooses the land price to maximize its expected fiscal revenue by attracting the firm, the city government should always consider other cities' land price offers.
- We use a Bertrand Game $\langle \mathbf{C}_i, (S_{ik}), (v_{ik}) \rangle$ to characterize the interaction between city governments when they compete for a firm i.
- We set city governments' pure strategy set $S_{ik} \equiv S = [p_{min},\ p_{max}]$ for $\forall i, k$.
- Space of mixed (and pure) strategy profile $\Sigma := (\Delta S)^{|\mathbf{C}_i|}$.
- For all i, a strategy profile $\delta \in \Sigma$ is Nash Equilibrium (NE) if for all $k \in \mathbf{C}_i$ and $p_{ik} \in S$:

$$v_{ik}(p_{ik}, \delta_{i(-k)}) \leq v_{ik}(\delta_{ik}, \delta_{i(-k)}).$$

- Based on computer simulations, we conjecture that every Bertrand Game $\langle \mathbf{C}_i, (S_{ik}), (v_{ik}) \rangle$ has a unique pure strategy Nash Equilibrium (and no mixed NE).

Numerical Method of Solving the Game

- We denote $P_{ik}(p_{ik}, p_{i(-k)}) := Pr(\text{i lands in k}|p_{ik}, p_{i(-k)})$.
- We derive the partial derivative of v_{ik} w.r.t. p_{ik}:

$$\frac{\partial v_{ik}}{\partial p_{ik}} = T_i P_{ik}(p_{ik}, p_{i(-k)}) \cdot \underbrace{\left[1 - \frac{1}{\sigma m}(1 - P_{ik}(p_{ik}, p_{i(-k)}))(\beta Y_i + p_{ik} T_i)\right]}_{f(p_{ik})} \tag{6}$$

$$f'(p_{ik}) = \underbrace{-\frac{1}{\sigma m}}_{<0} \cdot \left[\underbrace{-\frac{\partial P_{ik}(p_{ik}, p_{i(-k)})}{\partial p_{ik}}}_{>0} \underbrace{(\beta Y_i + p_{ik} T_i)}_{>0} + \underbrace{(1 - P_i(k))\, T_i}_{>0}\right] < 0 \tag{7}$$

$$\begin{aligned} \lim_{p_{ik} \to -\infty} f(p_{ik}) &= 1 \\ \lim_{p_{ik} \to +\infty} f(p_{ik}) &= -\infty \end{aligned} \tag{8}$$

Numerical Method of Solving the Game

- From (6), (7) and (8) we know v_{ik} is first increasing then decreasing in p_{ik} on $\mathcal{R}$ for any given $p_{i(-k)}$.
- This observation gives us the following theorem:

Theorem 1 (Uniqueness of Best Response).

For any Bertrand Game $\langle \mathbf{C}_i, (S_{ik}), (v_{ik}) \rangle$ and any city government k in $\mathbf{C}_i$: given other city governments' land price profile $p_{i(-k)}$, k's best response p^*_{ik} satisfies:

$$p^*_{ik} = \begin{cases} p_{min}, & \text{if } f(p_{min}) \leq 0 \\ p_{max}, & \text{if } f(p_{max}) \geq 0 \\ \text{the root of } f(p_{ik}) = 0, & \text{if } f(p_{min}) > 0 \text{ and } f(p_{max}) < 0 \end{cases} \tag{9}$$

- Theorem 1 immediately gives us a solver of the game based on Gauss-Jacobi algorithm.

Numerical Method of Solving the Game

Algorithm 1: Gauss-Jacobi algorithm to solve the Bertrand Game

Input: initial price vector p_i;
action space $[p_{min}, p_{max}]$;
$tol \leftarrow 1e-6$; `/* Convergence criteria */`
$max\_iter \leftarrow 10,000$; `/* Max number of iterations */`

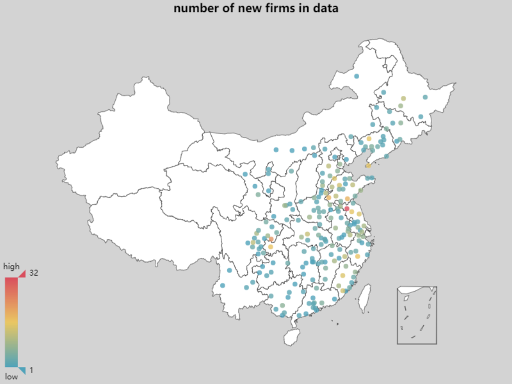
Result: NE price vector p_i^*

for *iter in* $1 : max\_iter$ **do**
  for k *in* $1 : |\mathbf{C}_i|$ **do**
    if $f(p_{ik} = p_{min}) \leq 0$ **then**
      $p_{ik}^* \leftarrow p_{min}$
    end
    else if $f(p_{ik} = p_{max}) \geq 0$ **then**
      $p_{ik}^* \leftarrow p_{max}$
    end
    else
      $p_{ik}^* \leftarrow$ the root of $f(p_{ik}) = 0$
    end
  end
  if $max_k(abs(p_{ik}^* - p_{ik})) < tol$ **then**
    return p_i^*
  end
  else
    $p_i \leftarrow p_i^*$
  end
end

Data

- We match 2013 Chinese industrial firm survey data, 2012 Chinese city statistics year book and official land selling data (from www.landchina.com) to get 1019 observations of new firms established in 2012.
- There are 212 cities which at least gets one firm in our data set.

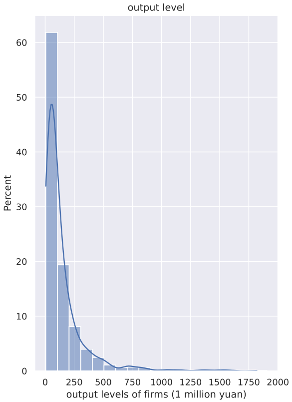
Number of firms each city lands in data

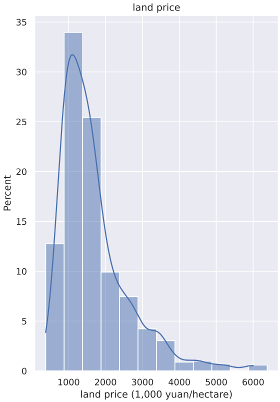


Data

- More than 80% of firms have output level have out put level between 5 million and 250 million yuan per year, and most of the firms buy land with price below 3 million yuan per hectare.

Sample distribution of output level and land price





Settings for Estimation

Inputs in the Bertrand Game model

	Name	Interpretation	Source	Value/Range/Formula
Parameters	β	governments' revenue share	estimation	$[0, +\infty)$
	σ	scale parameter in the distribution of ε_{ik}	estimation	$(0, +\infty)$
	α	capital income share	calibration	0.33
Variables	Y_i	output level of firm	data	
	L_i	number of workers in the firm	data	
	T_i	area of land usage	data	
	w_k	city average wage	data	
	B_i	firm's characteristic	data	$L_i w_{k^*}^{\alpha}$
	$\mathbf{C}_i$	firm's choice set	random draws	

- We set $|\mathbf{C}_i| = \ell(Y_i)$, and we define $\ell(Y_i)$ explicitly as:

$$\ell(Y_i) = \max\left\{3, 1 + \left\lceil 4 \cdot \frac{Y_i - Y_{\min}}{Y_{\max} - Y_{\min}} \right\rceil\right\} \tag{10}$$

- Then we draw $|\mathbf{C}_i|$ cities from the 10 nearest cities of the city where firm i lands in data as the choice set $\mathbf{C}_i$.

Moment Conditions

- We use method of simulated moments (MSM) to estimate $\theta = (\beta, \sigma)$.
- We use the mean, standard deviation, cube root of third order central moment, and median of observed land prices as sample moments, and match the simulated moments with the sample moments.
- We run $S = 10$ simulations by generating the choice set for each firm in each simulation.
- We denote the sample moments by h^{obs}, simulated moments by $h_S(\theta)$, and the moment conditions by $g(\theta) = h^{obs} - h_S(\theta)$.
- MSM estimates:

$$\hat{\theta} := (\hat{\beta}, \hat{\sigma}) = \underset{\beta \geq 0,\ \sigma > 0}{\arg\min}\ g(\theta)^{'} W g(\theta)$$

- We define $\Sigma := \text{Var}\left(h^{obs} - h_S^i(\beta, \sigma)\right) = \text{Var}\left(h_S^i(\beta, \gamma)\right)$.
- McFadden (1989) shows if $W = \Sigma^{-1}$, then $\text{AVar}(\hat{\theta}) = \frac{1}{N}(1 + \frac{1}{S})(D'\Sigma^{-1}D)^{-1}$, where the Jacobian $D = E(\frac{\partial h_S^i}{\partial \theta'})$.

Numerical Methods for Estimation

- We use a two-step method to get the estimates and standard errors.
- In the first step, we use the identity weighting matrix $W = I$ and calculate the MSM objective for all the (β, σ) combinations at the grids $\{0, 0.1, \cdots, 2.0\} \times \{100, 200, \cdots, 1000\}$.
- Then we do a finer search using Nelder-Mead algorithm starting from the grid point with the minimal MSM objective.
- In the second step, we use the estimates in first step to update W to the optimal weighting matrix $\hat{\Sigma}^{-1}$. And we do a Nelder-Mead search again starting from the estimates we get in the first-step to obtain the estimates and standard errors.

Estimation Results

Estimates of Parameters

Parameters	Estimates	Standard Error	95% Confidence Interval
β	0.745715	9.11e-6	[0.745697, 0.745733]
σ	426.514146	1.27e-5	[426.514121, 426.514171]

- If we assume city governments can only get value added tax revenue from industrial firms, city officials have 10 years term, and added value is 80% of the firm's output. Since VAT rate is 17%, the share of city governments in VAT revenue is 25%, then we have:

$$\beta \approx 10 \times 80\% \times 17\% \times 25\% = 0.34 < \hat{\beta} = 0.7457$$

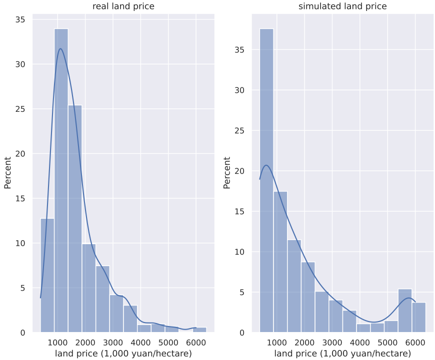
- Attracting firms bring city officials huge benefits besides the official tax revenue.
- That's why the fiscal competition is fierce between city governments.

Fit of the Model

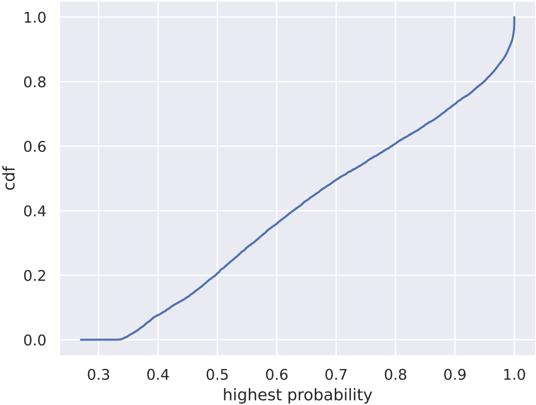
Sample moments and simulated moments

	Sample	Simulation
Mean	1685.10	1795.82
Standard deviation	934.49	1099.09
Cube root of third order central moment	1133.60	810.25
Median	1440.01	1405.18

Comparison of distribution of real land prices and simulated land prices



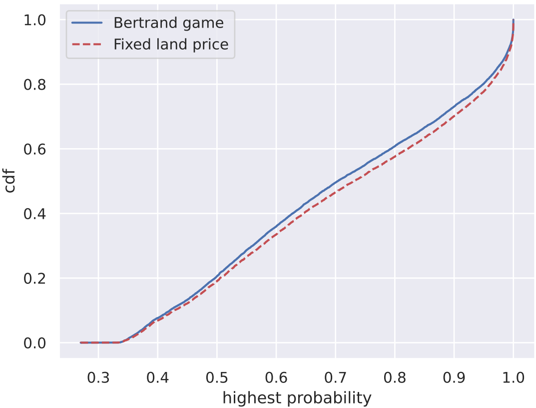
Empirical cdf of the highest probability of getting the firms



Allocation Efficiency

- The potential benefits of fiscal competition is the improvement of resources allocation between cities.
- We fix land price in the whole country, and compare the highest probability to get a firm across all firms and all simulations.
- In each simulation, for both cases of Bertrand Game and no fiscal competition (nation-wide fixed land price): for a given firm and a given choice set of the firm, the city with the lowest wage in the choice set always has the highest probability of getting the firm.
- But cities at disadvantage of attracting firms can increase the probability of landing the firms by decreasing the land price more sharply than others.

Comparison of two empirical cdfs of the highest probability



Allocation Efficiency

- The highest probability in Bertrand game is stochastically dominated by which under fixed land price.
- But fixing the land price (banning the fiscal competition) will increase this highest probability by only 1.4% on average.
- The impact of fiscal competition on allocation efficiency is very small.

Comparison of empirical distribution of the highest probability

highest probability	Bertrand game	fixed land price	difference
mean	0.7095	0.7240	0.0145
std	0.2085	0.2091	0.0006
min	0.2702	0.2702	0
25% percentile	0.5278	0.5389	0.0111
median	0.7038	0.7310	0.0272
75% percentile	0.9138	0.9336	0.0198
max	1.0000	1.0000	0
N $\times$ S	10190	10190	

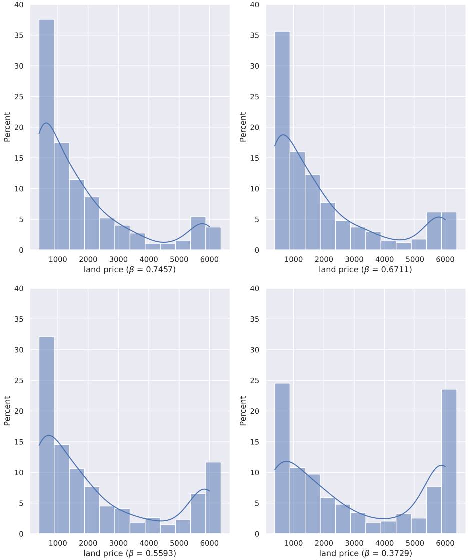
Impacts of fiscal centralization

- After 2013, the autonomy of local governments in economic and fiscal issues is declining due to the re-centralization of governance structure and anti-corruption movement, etc. All these political changes may depress the motivation of attracting firms, i.e. β may decrease.
- We examine the potential impacts of decrease of β by simulations.
- Decreasing the output share of local governments can increase the land selling revenue hugely since the benefits of fiscal competition is significantly lower for local governments.
- But the practical issue for fiscal centralization is how to compensate the fiscal revenue loss induced by the decrease of β.

The impacts of decrease in β

β	change of β	average land price	total land selling revenue	total fiscal revenue
0.6711	-10%	10.35%	8.51%	-9.21%
0.5593	-25%	29.14%	24.29%	-22.91%
0.3729	-50%	68.13%	60.19%	-45.32%

Change of land price distribution due to decrease of β



Impacts of the Rising Wage Level

- The rising urban wage in China after late 2000s is caused by the rural surplus labor supply crossing the Lewisian turning point (Cai & Wang, 2010) and the age structure change (Cai, 2016).
- Thus, land price in firms' location choice problem will be less important. And the local governments will rise the land price since firms are not as much sensitive to land price as before.
- But the impacts of wage increase on land price is very limited.
- This implies it might be difficult to change the pattern of fiscal competition by the change of production factor prices (by pure market power).

The impacts of increase in wage level

wage increase	average land price	land selling revenue	total fiscal revenue
10%	1.25%	2.15%	0.09%
25%	3.01%	5.18%	0.22%
50%	5.45%	9.53%	0.40%

Conclusion

- Local governments can get huge benefits from attracting industrial firms. And the ratio of fiscal revenue to firms' output is much higher than the official tax rate.
- The major tool for the fiscal competition: selling industrial land at low price cannot improve the allocation efficiency of output but waste a lot of potential land selling revenue.
- The real potential benefits of the fiscal competition can only come the case that more firms (or output level) are created due to the lower production cost induced by the efforts of local governments to attract firms. But this issue is beyond the scope of our model.
- The mode of fiscal competition faces potential challenges, such as the decline of economic autonomy of local governments and rising wage.

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