Urbanization Policy and Economic Development: A Quantitative Analysis of China's Differential Hukou Reforms

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Motivation

- Migration and urbanization are instrumental to an economy's industrialization and growth, and China is no exception.
- The relax of the hukou system had lead to the largest wave of migration and urbanization in human history.
- However, in the most recent decade, a perplexing pattern had emerged in China: *instead of moving to the productive large cities, the rural migrants predominately favor the small- and medium-sized cities.*
- Our question: why is this the case, and what are the implications?

This Paper

- Empirically documents the striking contrast in the migration patterns between years 2005 and 2015.
  - The probabilities of a rural migrant moving to large and small cities are roughly the same during 2000-2005.
  - The probability of a rural migrant moving to large cities is much smaller than that to small cities during 2010-2015.
- Builds a trade and urban model to disentangle the four potential forces for explaining the observed pattern: productivity, amenity, housing prices, and migration policy in general equilibrium.
- Shows that the **differential reforms** in the migration policy that discriminate against the large cities are key factors for the changes in migration pattern.
- Evaluates the costs of such differential reforms.

Why are Differential Reforms Costly? And, How Much?

- Intuition: Spatial Misallocation: If large cities are more productive than the small- and medium-sized ones, intentionally directing more rural migrants towards these small- and medium-sized cities imply a loss in aggregate productivity and welfare.
- This is analogous to Hsieh and Moretti (2019) who quantitatively demonstrate the large negative impact of stringent housing restrictions in the most productive cities in the US on the aggregate output and welfare.
- How large are the welfare costs?
  - In a nutshell, when China adopts a more uniform or laissez-faire migration policy, the gains are comparable to those gains from trade liberation such as entering the WTO.

Literature

- Internal migration in China (Tombe and Zhu, 2019; Fan, 2019; Ma and Tang, 2020b; Zi, 2020; An et al., 2020)
  - An et al. (2020) show reduced-form evidence that a particular 2014 differential reform led to differential effects on labor market outcomes.
  - Our finding on the changes of the migration pattern suggests that the differential reforms started much earlier.
  - We provide a comprehensive welfare analysis.
- Spatial quantitative economics (Hsieh and Moretti, 2019; Redding, 2016; Redding and Rossi-Hansberg, 2017; Artuç, Chaudhuri and McLaren, 2010; di Giovanni, Levchenko and Ortega, 2015; Fajgelbaum, Morales, Surez Serrato and Zidar, 2018; Caliendo, Parro, Rossi-Hansberg and Sarte, 2018; Caliendo, Dvorkin and Parro, 2019)

The Differential Policy

- The hukou system as the main policy instrument – a remnant from the command-economy regime under Mao.
- Starting from the 11th and the the 12th Five-Year Plans (2006 to 2010, 2011 to 2015), the central government started the differential reform:

  "Rural migrants should be encouraged to move into small and medium sized cities, while the population growth in mega cities should be controlled and contained"
- The official policy formalized in 2014 State Council Opinion: all towns and small cities with population below 500,000 to abandon restrictions on hukous. The same policy also re-affirms "strictly controlling" the size of mega cities with population above 5 million.

The Impacts of the Differential Policy?

The migration patterns are drastically different before and after such a policy, as shown from the *One Percent Population Survey*:

	Rural (o)	Large (o)	Small (o)
Rural (d)	0.944	0.033	0.070
Large (d)	0.029	0.959	0.024
Small (d)	0.028	0.008	0.907

(a) Migration Probability, 2005

	Rural (o)	Large (o)	Small (o)
Rural (d)	0.623	0.078	0.180
Large (d)	0.083	0.894	0.079
Small (d)	0.294	0.027	0.742

(b) Migration Probability, 2015

Table 1: Matrices of Migration Probability

The Model

The Model

Melitz (2003) + Migration + Within-City Structures

- M **countries**, within each, a number of **regions**. A country-region combination a **"location"**, and use i or j to index the locations.
- A region is either **"urban"** or **"rural"**. Two differences:
  - Urban regions produce differentiated products while rural regions produce a homogeneous agriculture product.
  - Within each urban region, Alonso-Muth-Mills monocentric city structure. This captures the housing and commuting costs.
- Intra-national trade is frictionless while international trade is not.

The Utility Function

An individual living (in a representative city) in an urban region i and at a distance z from the central business district (CBD):

$$U_i(z) = \frac{\alpha^{-\alpha}\gamma^{-\gamma}(1-\alpha-\gamma)^{-(1-\alpha-\gamma)}}{d(z)} \times \phi_i \left(y_i^A\right)^{\alpha} \left[\sum_{j=1}^{J} \int_{k\in\Omega_{ij}} y_{ij}(k)^{\frac{\varepsilon-1}{\varepsilon}} dk\right]^{\frac{\gamma\varepsilon}{\varepsilon-1}} \ell_i^{1-\alpha-\gamma},$$

- ϕ_i is the amenity;
- y_i^A is the consumption of the agriculture product;
- $y_{ij}(k)$ is the consumption of variety k purchased from location j;
- ℓ_i is the consumption of land space.
- In the rural regions, $d(z) = 1$.

Urban Production

Production function of firm k in urban location i:

$$q_i(k) = \frac{1}{a(k)} b_i(k),$$

where $1/a(k)$ is the productivity, and $b_i(k)$ is the input bundle:

$$b_i(k) = \beta^{-\beta}(1-\beta)^{-(1-\beta)} [n_i(k)]^{\beta} \left[\left(\sum_{j=1}^{J} \int_{k' \in \Omega_{ij}} y_{ij} \left(k'; k\right)^{\frac{\varepsilon-1}{\varepsilon}} dk' \right)^{\frac{\varepsilon}{\varepsilon-1}} \right]^{1-\beta}$$

where $n_i(k)$ is the employment of firm k.

Urban Production

Standard Melitz assumptions:

- firms draw productivity $(1/a)$ from a location-specific Pareto distribution:

$$\Pr\left(\frac{1}{a} < x\right) = 1 - \left(\frac{\mu_j}{x}\right)^{\theta},$$

- where θ is the tail index and μ_j is the parameter that reflects the average productivity in location j. A higher μ_j implies that the average draw of a is lower in j.
- a large pool of potential entrants. To enter production in location j, an entrant must pay f_e units of input bundles acquired in location j. Upon paying the entry cost, the firm draws its productivity from $G_j(a)$, based on which it decides whether to produce or to exit.

Rural Production

The production in the agriculture sector requires the input bundle b_j^A, subject to a productivity parameter μ_j^A:

$$q_j^A = \mu_j^A b_j^A.$$

The input bundle to agriculture production is a Cobb-Douglas combination of labor (N_j), land (L_j), and intermediate goods:

$$b_j^A = \nu^{-\nu}\eta^{-\eta}(1-\nu-\eta)^{-(1-\nu-\eta)} \times$$
$$(N_j)^{\upsilon}(L_j)^{\eta}\left[\left(\sum_{j=1}^{J}\int_{k'\in\Omega_{ij}} y_{ij}(k';k)^{\frac{\varepsilon-1}{\varepsilon}}\,dk'\right)^{\frac{\varepsilon}{\varepsilon-1}}\right]^{1-\upsilon-\eta}$$

The Monocentric City

- The monocentric city is a disk with a radius $\bar{z}_i$. One can travel from any place in the disk to the CBD at the center via a straight line.
- Every individual in the city works in the CBD; the city radius $\bar{z}_i$ is endogenously determined.
- Different locations z face the same prices of agricultural and differentiated goods but different commuting costs $d(z)$ and land rents $R_i(z)$.
- In equilibrium, consumption utilities in different places z are equalized, which implies that the land rent $R_i(z)$ decreases in z.
- An outside land value $\bar{R}_i$ help determined the city edge $\bar{z}_i$: we treat $\bar{R}_i$ as a parameter to be calibrated. Alternative: use the equilibrium agriculture land rent.

Rural Land Market and the Land Rent Rebate

- In the rural region, $d(z) = 1$, e.g. people live on farms. They still pay land rent.
- Assume the two rural land uses (agricultural production and residential) are perfect substitutes, and hence one land price clears the land market in each rural region.
- We do not assume absentee landlords; we assume that every individual in every country c owns an equal share of the land in the country,
- Hence the aggregate land rent in this country is rebated to each citizen evenly. The rebated amount to an individual is denoted as T_c.

Migration

- The indirect utility for an individual at an urban region i in country c and at a distance z from the CBD is given by

$$v_i(z) = \frac{\phi_i (w_i + T_c)}{d(z) \left(P_i^A\right)^{\alpha} (P_i)^{\gamma} R_i(z)^{1-\alpha-\gamma}},$$

  - $v_i(z) = \bar{v}_i$ in equilibrium for all z within the same city.
- Each individual draws an idiosyncratic preference shock toward each location $\{\iota_i\}_{i=1}^{J}$ that follows a Fréchet distribution:

$$F(\iota_i) = \exp\left[-(\iota_i)^{-\kappa}\right],$$

- Lastly, bilateral migration costs, λ_{ij}, apply. An individual living in location j will migrate to i if and only if living in i provides him with the highest utility:

$$\frac{\bar{v}_i \cdot \iota_i}{\lambda_{ij}} \geq \frac{\bar{v}_{i'} \cdot \iota_{i'}}{\lambda_{i'j}}, \quad \forall\ i' \in J_c.$$

Spatial Equilibrium

Definition: An equilibrium consists of a tuple of prices $\{w_j, p_{ij}(.), P_j^A, R_j(.)\}_{i,j}$, a tuple of quantities $\{N_j, I_j, q_{ij}(.), y_{ji}(.), y_{ji}(, ; .), y_j^A, \ell_j(.), \bar{z}_j\}$ for each location i and each urban location j, and a tuple of quantities $\{N_j, q_j^A, L_j, y_{ji}(.), y_j^A, \ell_j\}$ for each location i and each rural location j such that the following conditions hold:

(a) Individuals maximize their utility by choosing locations (including the places of residence within a city if the location is an urban region), residential land consumption, and the consumption bundles from both sectors.

(b) Each firm maximizes its profits by choosing which markets to sell to and the prices charged to each market.

(c) The free-entry condition holds in each location.

(d) The agriculture market clears in each location.

(e) Within each urban region j, land rent $R_j(.)$ clears the urban land market so that urban residents are indifferent across places of residence, $v_j(.) = \bar{v}_j$ and that the city edge $\bar{z}_j$ is such that $R_j\left(\bar{z}_j\right) = \bar{R}_j$.

(f) In any rural region j, the land rent R_j clears the land market so that the aggregate land demand $L_j + N_j\ell_j$ equals to total land endowment there.

(g) The differentiated goods market clears such that the aggregate expenditure on the differentiated goods in location i equals the final consumption $(1-\alpha)\, w_i N_i$ and intermediate goods use $(1-\beta)\, X_i$: $X_i = (1-\alpha)\, w_i N_i + (1-\beta)\, X_i$.

(h) Labor market clearing for each country c: $\sum_{j \in J_c} N_j = \bar{N}_c$.

Analytical Solution: Trade Side

Conditional on the population distribution, standard Melitz results apply:

$$\chi_j = (w_j)^{\beta} (P_j)^{1-\beta}$$
$$p_{ij}(k) = \frac{\varepsilon}{\varepsilon - 1} \tau_{ij} \chi_j a(k)$$
$$q_{ij}(k) = \frac{X_i}{(P_i)^{1-\varepsilon}} [p_{ij}(k)]^{-\varepsilon}$$
$$\pi_{ij}(a) \equiv \max_{p_{ij}(k)} p_{ij}(k) q_{ij}(k) - a(k) q_{ij}(k) \tau_{ij} \chi_j,$$

The firm in j sells to i if and only if its $a(k)$ is less than a_{ij}:

$$a_{ij} = \frac{\varepsilon - 1}{\varepsilon} \frac{P_i}{\tau_{ij} \chi_j} \left(\frac{X_i}{\varepsilon \chi_j f_{ij}} \right)^{\frac{1}{\varepsilon - 1}}.$$

In equilibrium, the expected profit in location j must be equal to the entry:

$$\overline{\Pi}_j = f_e \chi_j.$$

Analytical Solution: Urban Side I

- The income of an individual in an urban region i in country c is given by $w_i + T_c$
- Following Ahlfeldt et al. (2015), $d\left(z\right) = e^{\delta t z}$: travel time is linear in distance.
- The population density at each point z is the inverse of land use per person, i.e., $1/\ell_i(z)$. The land market clearing condition is therefore:

$$\hat{N}_i = \int_0^{\bar{z}_i} 2\pi z \frac{1}{\ell_i(z)} dz.$$

- The RHS is the implied total population from the equilibrium land consumption, $\ell_i(z)$:

$$\ell_i(z) = \left(1 - \alpha - \gamma\right)\left(w_i + T_c\right)/R_i(z)$$

- Using $R_i\left(\bar{z}_i\right) = \bar{R}_i$, one can arrive at the equilibrium land rent as well

$$R_i(z) = \bar{R}_i e^{\frac{\delta t\left(\bar{z}_i - z\right)}{1-\alpha-\gamma}}.$$

Analytical Solution: Urban Side II

- Integrate population density over the disk:

$$e^{\frac{\delta t \bar{z}_i}{1-\alpha-\gamma}} - \left(1 + \frac{\delta t \bar{z}_i}{1-\alpha-\gamma}\right) = \frac{\delta^2 t^2 (w_i + T_c) \hat{N}_i}{2\pi (1-\alpha-\gamma) \bar{R}_i}.$$

- Taking $(w_i + T_c)$ and $\hat{N}_i$ as given, this is the single equation that pins down the city radius $\bar{z}_i$ and summarizes the information on commuting costs and land rents.

The Aggregate Land Rent

The Cobb-Douglas structure implies that the aggregate land rents in an urban region i and the aggregate residential land rents in a rural region i are both given by $(1-\alpha-\gamma)(w_i + T_c) N_i$:

$$T_c = \frac{R_{A,c} L_{A,c} + (1-\alpha-\gamma) \sum_{i \in J_c} (w_i + T_c) N_i}{\bar{N}_c},$$

which entails

$$T_c = \frac{R_{A,c} L_{A,c} + (1-\alpha-\gamma) \sum_{i \in J_c} w_i N_i}{(\alpha+\gamma) \bar{N}_c}.$$

Migration Decision

It is straightforward to show that conditional on $\{\bar{v}_i\}_{i \in J_c}$, the fraction of the population that migrates from j to i in country c is

$$m_{ij} = \frac{(\bar{v}_i)^{\kappa} (\lambda_{ij})^{-\kappa}}{\sum_{i' \in J_c} (\bar{v}_{i'})^{\kappa} (\lambda_{i'j})^{-\kappa}}.$$

Note that κ is the migration elasticity with respect to friction. The larger the κ, the less heterogeneous the idiosyncratic locational preferences, and hence the more sensitive migration flows are to changes in migration friction.

Quantification

Quantification

- Three countries: China (CHN), other developing countries (ODC), and the rest of the world (ROW). 64 countries in the sample. The countries with the average per capital GDP less then 2/3 of the USA into the "other developing countries", and the rest as the ROW.
- China is divided into three regions: rural, the Mega Urban Regions (MUR), and the other urban regions (OUR). The other two countries only contain one rural and one urban region each. MUR contains all the cities with a population greater than 5 million.
- Calibrate the model to two years, 2005 and 2015.

Common Parameters

Some parameters are fixed across the two years:

Name	Value	Source	Note
α	0.15	Input-Output Table, 2002	Expenditure share in agricultural goods
γ	0.785	Ahlfeldt et al. (2015)	Expenditure share in the differentiated products
β	0.37	Input-Output Table, 2002	Labor share in differentiated goods production
ε	4.717	Firm size distribution in China	Elasticity of substitution
θ	4.0	Simonovska and Waugh (2014)	Trade elasticity and the Pareto tail index in productivity distribution
κ	1.63	Ma and Tang (2020a)	Migration elasticity and the shape parameter in location preference
δ	0.01	Ahlfeldt et al. (2015)	The elasticity of commuting costs with respect to distance
t	4.35	Baidu Commuting Data	The size of commuting costs

Year-Specific Parameters

- **Initial Population** Census data in 2000 and 2010.
- **Trade Costs** ICIO from OECD and Novy (2013). Allowing for different trade costs of agriculture products, using ESCAP-World Bank Trade Cost Database.
- **Productivity**
  - Urban TFP in China: Ma and Tang (2020b).
  - Urban TFP in the other countries: PWT.
  - Production function in agriculture: the USDA-ERS database.
  - Rural TFP: residual estimation from the USDA-ERS database.
- **Outside Land Value** CBD Land Price Database in China.

Joint Calibration: Overview

All the above parameters can be calibrated without solving the model. The rest needs to be jointly and iteratively calibrated: amenity ϕ_i, migration costs, λ_{ij}, and the costs of entry, f_e:

- With an initial guess of λ_{ij}, use the bilateral migration flow data, the equilibrium migration equation, and the definition of amenity to estimate ϕ_i.
- Conditional on ϕ_i, we solve the model and jointly calibrate the remaining 7 parameters (f_e and λ_{ij}) using 7 moments in the data.
- Iterate back to Step 1 until λ_{ij} converges to a pre-set threshold.

Joint Calibration: Step 1, Estimating ϕ_i

Conditional on a guess of λ_{ij}:

1. The equilibrium population flow:

$$\log(m_{ij} N_j) = \kappa \log(\bar{\nu}_i) + \log(N_j) - \log\left(\sum_{i' \in J_c} (\bar{\nu}_{i'})^{\kappa} (\lambda_{i'j})^{-\kappa}\right) - \kappa \log(\lambda_{ij}).$$

   In a city-level regression with the destination and origin fixed effects, the destination fixed effect of region i is $\mathbf{D}_i = \kappa \log(\bar{\nu}_i)$.

2. Rewriting the definition of $\bar{\nu}_i$:

$$\log(\bar{\nu}_i) = \log(\phi_i) - \delta t \bar{z}_i + \log\left[\frac{w_i + T_i}{(P_i)^{\alpha} P_i^{\gamma} \bar{R}_i^{1-\alpha-\gamma}}\right].$$

   re-arrange:

$$\frac{1}{\kappa}\mathbf{D}_i = -(1-\alpha-\gamma)\log(R_i(0)) + \log\left[\frac{w_i + T_i}{(P_i)^{\alpha} P_i^{\gamma}}\right] + \log(\phi_i)$$

   ϕ_i is in the residual.

Joint Calibration: Step 1, Estimating ϕ_i

Conditional on a guess of λ_{ij}:

3. Linearly project the residual from the previous step, denoted as $\mathbf{e}_i$, on a vector of city-level characteristics, $\mathbf{X}_i$, that is potentially related to amenity:

$$\mathbf{e}_i = \mathbf{b}_0 + \mathbf{b}_1 \mathbf{X}_i,$$

4. Use the prediction from the projection as the estimate for $\log(\phi_i) = \widehat{\mathbf{b}}_1 \mathbf{X}_i$.

$\mathbf{X}_i$ includes the average temperature, precipitation, elevation, and slope; the number of universities, middle schools, and primary schools, the number of university, middle school, and primary school teachers, the number of public library books; the number of hospitals, hospital beds, and doctors; the percentage of green fields in constructed areas, and the ease of access to transportation networks.

Joint Calibration: Step 2, Calibrating λ_{ij} and f_e

Conditional on ϕ_i, we can solve the mode and calibrate the last 7 parameters 6 λ_{ij} and f_e by targeting 7 moments:

- The firms-to-population ratio in the MUR, from the Economic Census.
- The six migration probabilities from the *One Percent Population Survey.*

We then iterate back to step 1 to re-estimate ϕ_i until convergence.

The Quantitative Results

Productivity, Amenity, and Housing Prices

- Productivity and amenity are unlikely to be the culprit.
- The land price, on the other hand, might be responsible. The land supply policy is part of the differential reform that restricts the mega cities.

	MUR	OUR
μ, 2005	1.000	0.860
μ, 2015	1.290	1.110
ϕ, 2005	0.90	1.05
ϕ, 2015	1.00	0.99
$\bar{R}$, 2005	124.24	51.65
$\bar{R}$, 2015	657.16	125.15

The Migration Policy

The migration policy clearly favors the smaller cities:

	Rural (o)	MUR (o)	OUR (o)
Rural (d)	1.00	2.95	1.89
MUR (d)	22.98	1.00	9.94
OUR (d)	22.28	17.40	1.00
f_e	7.56		

(a) λ_{ij}, 2005

	Rural (o)	MUR (o)	OUR (o)
Rural (d)	1.00	1.78	1.14
MUR (d)	8.59	1.00	4.76
OUR (d)	3.31	7.08	1.00
f_e	11.29		

(b) λ_{ij}, 2015

Table 2: The Estimated λ_{ij}

Evaluating the Differential Reforms and Housing Price

Three counter-factuals:

- **The "λ^* counter-factual"** Set $\lambda_{31} = \lambda_{21} = \lambda^*$ so that the rural population face the same barriers into the two urban regions. Pick the value of λ^* so that the same number of the rural population chooses to move out as in the baseline.
- **The "low λ counter-factual"**, we equalize the two rural-urban migration friction to the lower value of the two, so that $\lambda_{31} = \lambda_{21} = \min\{\lambda_{31}, \lambda_{21}\}$.
- **The "low $\bar{R}_{\mathbf{MUR}}$ counter-factual"**: lower the $\bar{R}$ in MUR so that $\bar{R}_{\text{MUR}}/\bar{R}_{\text{OUR}}$ in 2015 is the same as in 2005.

Migration Flows Revert as Compare to the Baseline

	Rural (o)	Large (o)	Small (o)
Rural (d)	0.623	0.078	0.180
Large (d)	0.083	0.894	0.079
Small (d)	0.294	0.027	0.742

(a) Baseline λ

	Rural (o)	MUR (o)	OUR (o)
Rural (d)	0.623	0.077	0.180
MUR (d)	0.218	0.896	0.080
OUR (d)	0.159	0.027	0.741

(b) λ^*

	Rural (o)	MUR (o)	OUR (o)
Rural (d)	0.488	0.082	0.189
MUR (d)	0.296	0.892	0.079
OUR (d)	0.216	0.027	0.731

(c) Low λ

	Rural (o)	MUR (o)	OUR (o)
Rural (d)	0.619	0.073	0.179
MUR (d)	0.090	0.901	0.084
OUR (d)	0.291	0.026	0.737

(d) Low $\bar{R}_{\text{MUR}}$

The Welfare Costs of the Differential Reforms

	China	Rural	Coastal	Inland	Rural ODC	Urban ODC	Rural ROW	Urban ROW
				Baseline 2015				
L_i	2.1847	0.6627	0.5209	1.0011	1.4761	3.0510	0.0322	1.3668
Real Wage	0.2439	0.1191	0.3326	0.2802	0.5588	2.5655	17.0559	11.8943
Operating Firms	1.2018	-	0.6097	0.5921	-	85.9509	-	2823.1143
Exporting Firms	0.2012	-	0.1021	0.0991	-	5.3086	-	24.1176
				$\lambda_{21} = \lambda_{31} = \lambda^*$				
L_i	2.1847	0.6625	0.6183	0.9038	1.4761	3.0510	0.0322	1.3668
Real Wage	0.2507	0.1209	0.3410	0.2841	0.5586	2.5643	17.1475	11.8910
Operating Firms	1.1007	-	0.6353	0.4654	-	82.8835	-	2725.1188
Exporting Firms	0.2048	-	0.1182	0.0866	-	5.1213	-	23.2703
				Low λ				
L_i	2.1847	0.5800	0.6711	0.9336	1.4761	3.0510	0.0322	1.3668
Real Wage	0.2692	0.1304	0.3542	0.2944	0.5553	2.5490	17.7685	11.8370
Operating Firms	0.8074	-	0.4760	0.3314	-	54.9881	-	1821.0142
Exporting Firms	0.1469	-	0.0866	0.0603	-	3.4083	-	15.5018

Comparing to Trade Liberalizations

How large are these welfare costs? Compare this with trade liberalization. In our model:

- The welfare gain from the λ^* counter-factual is 2.8%, which is equivalent to a 6.5% of bilateral trade liberalization of China.
- The gain from the low λ counter-factual is 10.4%, which is equivalent to a 19.3% bilateral trade liberalization.

ESCAP-World Bank Trade Costs Database, China only lowered its average variable trade costs by 5.1% during 1996–2006, which was the period when it entered the World Trade Organization (at the end of 2001) and when tariffs were substantially reduced.

Conclusion

- A striking contrast in the migration patterns between years 2005 and 2015: why rural migrations prefer the smaller cities in 2015?
- Such a migration pattern is consistent with the differential reforms on the hukou system.
- Correcting the bias against the large cities lead to sizable welfare gains comparable to the effects of joining WTO.

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