

Structural Change and Food Security Constraints: A Market Solution

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Motivation

- Economic development is accompanied by **structural change**: large-scale rural-to-urban migration increases the demand for urban land.
- One way to expand urban land supply is to convert farmland, but doing so **threatens food security**. The central government in China imposed strict restrictions on converting farmland (*farmland redline policy, urban land construction quota*).
- The local government of Chongqing introduced a creative market-based solution: **the Land Coupon system**, which creates a market for rural residential land and expands urban land supply without reducing farmland.

Reclamation of rural residential land to farmland

- **Rural HHs:** reclaim rural residential land to farmland → **generate** coupons (extra quota)
- **Urban developers:** **purchase** coupons → develop peri-urban farmland to urban land



This Paper

Research Question:

Can a market for rural residential land support structural change under food-security constraints?

A Policy Experiment: Chongqing land coupon reform since Dec 2008

What I do:

- **Collect** comprehensive land coupon transaction data
- **Document** the spatial pattern of land coupon flows
- **Build** a quantitative spatial model to evaluate its impacts

Preview of Findings

Empirical Facts

- **Lower initial ag. productivity** (value added per worker) is associated with:
 - **more** land coupon supply
 - **larger** rural-to-urban migration
- **Higher land coupon supply** is associated with: **higher** grain yield growth

Counterfactual: shutting down the land coupon market

- Urban residential land -14.0% ; urban rent $+15.1\%$
- Shadow price of the land quota rises from 300 to 2,336 yuan/m²: **the coupon market cuts it by 87%**
- Rural-to-urban migration -0.6% ; ag. labor productivity -0.6%

Contributions

① Rural land market

- Existing literature emphasizes the market for *farmland*
This paper: the market for rural *residential* land also matters for structural change

② Linking rural and urban land markets

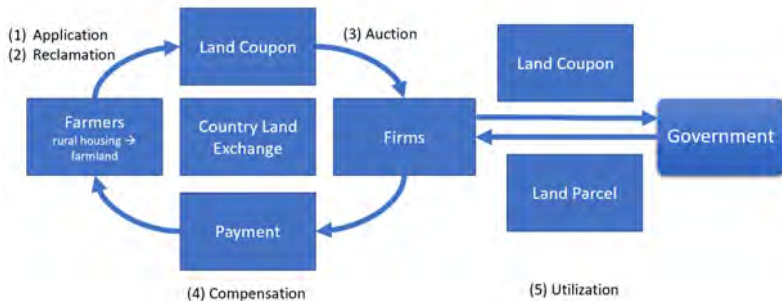
- Land-use regulations often constrain urban expansion
This paper: tradable development rights connect rural land reclamation to urban land supply

Related Literature

- ❶ **Farmland property rights:** *de Janvry et al. (2015); Chen (2017); Chari et al. (2021); Bu and Liao (2022); Liu et al. (2023); Adamopoulou et al. (2024); Chen et al. (2025)*
- ❷ **Land use regulations, especially urban land quotas:** *Fu et al. (2021); Henderson et al. (2022); He et al. (2023); Lu et al. (2023); Fang et al. (2025); Ding et al. (2025); Wang et al. (2025); Yu (2026)*
- ❸ **Quantitative spatial model to evaluate land and labor misallocation:** *Hsieh and Moretti (2019); Deng et al. (2020); Liang et al. (2024); Fang et al. (2026); Wang and Zhang (2025); Yu (2026);*
- ❹ **Tradable rights in mitigating misallocation under regulatory constraints** *Coase (1960); Mills (1980); Wang et al. (2010); Aranson (2012); Goulder (2013);*

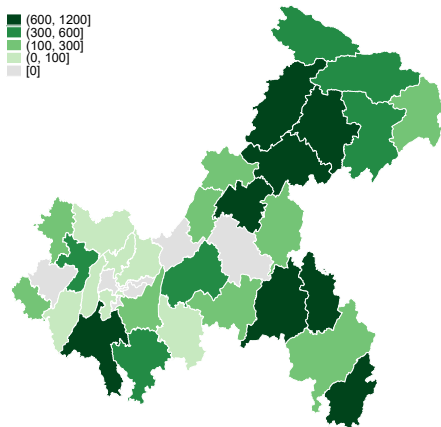
Land Coupon Reform in Chongqing

- **Pre-reform:** urban expansion was constrained by **urban land quotas** allocated by central gov.
- **Reform (Dec 2008):** reclaiming rural residential land to **farmland** generates **coupons**, which developers buy to convert peri-urban farmland. Supplier
 - urban land quota=central gov. allocation + market-generated coupon

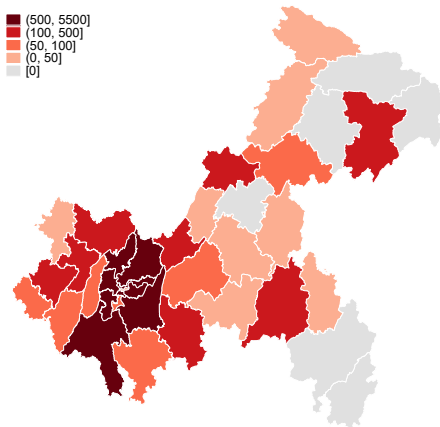


Coupons flow from remote rural counties to urban-fringe development areas

Land coupon supplied area (ha) (2008-2015)

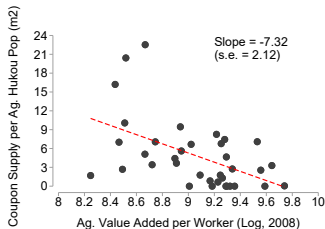


Land coupon purchased area (ha) (2008-2015)

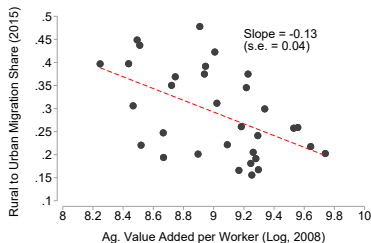


Descriptive Patterns Motivating the Model

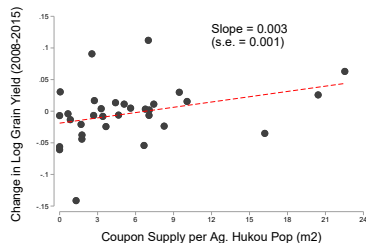
Fact 1: Lower Ag. VA & More Coupon



Fact 2: Lower Ag. VA & Higher Migration



Fact 3: Coupon Supply & Yield Growth



Overview of Model

Heterogeneous Farming Ability + **Internal Migration** + **Land Coupon Market**
(*Adamopoulos et al., 2022*) (*Tombe and Zhu, 2019*) (link rural and urban land)



**1. Urban land supply ↑
& Urban rent ↓**

**2. Rural-to-urban
migration ↑**

**3. Aggregate ag. labor
productivity ↑**

- N rural regions in Chongqing (ag. sector)
- One urban region in Chongqing and one urban region outside Chongqing (non-ag. sector)
- Farmers are endowed with rural residential land δ_n^h and rural farmland δ_n^f
- Small and open economy, p_{ag} and p_{na} exogenous

Preference

- Individual i born in rural region n chooses destination $m \in \{n, u, o\}$: stay / Chongqing urban / outside Chongqing
- Utility from goods and housing consumption:

$$U_{nm}(i) = \frac{\left[(c_{nm}^{ag}(i))^\varphi (c_{nm}^{na}(i))^{1-\varphi} \right]^\alpha (h_{nm}(i))^{1-\alpha}}{\mu_{nm}} \cdot \epsilon_{nm}(i) \quad (1)$$

- $\epsilon_{nm}(i)$: idiosyncratic preference for m , i.i.d. Fréchet $F_\epsilon(x) = \exp(-x^{-\rho})$, $\rho > 1$
- Housing: rural stayers consume $h_{nn}(i) = \delta_n^h - s_n^{coupon}(i)$ (convert rural residential land to farmland and create coupon supply); migrants rent $h_{nm}(i)$ at r_m
- μ_{nm} : migration cost, with $\mu_{nn} = 1$ and $\mu_{nm} > 1$ for $m \neq n$

Agricultural Sector Production

- **Agricultural sector (rural n):** farmer i with idiosyncratic productivity $z_n^{ag}(i)$ chooses farm size $s_n^f(i)$ to maximize profit

$$\max_{s_n^f(i)} \pi(z_n^{ag}(i)) = p_{ag} (A_n^{ag} z_n^{ag}(i))^{1-\beta} s_n^f(i)^\beta - q_n (s_n^f(i) - \delta_n^f) \quad (2)$$

- $z_n^{ag}(i) \sim \text{Fréchet: } F(z) = \exp(-z^{-\theta}), \theta > 1$
- farmland rented in/out within n with rental rate q_n

Non-agricultural Sector Production

- **Non-agricultural sector (Chongqing urban):** representative firm profit maximization

$$\max_{\{L_u^{na}\}} \pi(L_u^{na}) = p_{na} A_u^{na} L_u^{na} - w_u^{na} L_u^{na} \quad (3)$$

$$L_u^{na} = \sum_n m_{nu} \bar{N}_n + \bar{h} N_u^U, \quad N_u^U = \bar{N}_u m_{uu}^U + \bar{N}_o m_{ou}^U$$

- na ability: rural-born migrants normalized to 1; urban-origin workers $\bar{h} \geq 1$
- $m_{nu} \bar{N}_n$: migrants from rural region n to Chongqing urban
- N_u^U is endogenous: urban-origin workers choose between Chongqing and the outside city

[detail](#)

Urban Land Market: Developer

- A representative developer chooses residential **land** x_u using non-coupon capacity $B_{u,H}^0$ and land coupons D_u^H ; floor space is $H_u = \eta x_u$
- Profit maximization:** all four regimes

$$\max_{\{x_u, D_u^H\}} \pi = \eta \left(r_u - c_u^B \right) x_u - G_u(x_u) - t D_u^H - \tau x_u \quad \text{s.t.} \quad x_u \leq B_{u,H}^0 + D_u^H \quad (4)$$

- r_u : rental rate of urban floor space; c_u^B : construction cost per unit of floor space
- Land-development cost $G_u(x_u) = (1 + 1/\xi)^{-1} \psi_u x_u^{1+1/\xi}$, marginal cost is $p_u^L(x_u) = G'_u(x_u) = \psi_u x_u^{1/\xi}$
- η : floor-area ratio; $B_{u,H}^0$: residential land available without coupons; t : coupon price;
- τ : wedge (taxes, fees, normal profit)

Individual Decision: Coupon Supply and Migration

- **Coupon supply decision:** detail
 - Coupon transaction with probability b
 - Optimal coupon supply
 - Cutoff productivity
- **Migration decision:**
 - Indirect utility farmer migrant
 - Rural-to-urban migration share migration share

Equilibrium: Three Linked Markets

- **Market clearing conditions**

- Farmland market [detail](#)
- Urban residential land market [detail](#)
- Land coupon market [detail](#)

- **Definition of competitive equilibrium** [competitive equilibrium](#)

Model Mechanism

① Urban land market becomes less constrained

- Developers buy coupons to expand residential land
- Urban rent declines

② Rural-to-urban migration increases

- Coupon compensation raises migrants' expected income and payoff from moving
- More urban land supply lowers urban housing rent

③ Aggregate agricultural labor productivity increases

- Less productive farmers are more likely to leave agriculture
- Farmland is reallocated toward more productive farmers, and reclamation adds farmland

Take the Model to Data: Overview

- **Data Used** (32 rural counties + 1 urban region in Chongqing + 1 outside region)
 - ① County-level land coupon supply from *Chongqing Rural Land Exchange*
 - ② County-level migration share from *Population Census*
 - ③ County-level ag and city-level na output value, population from *Chongqing Statistical Yearbook*
- **Externally Calibrated** (from literature and data) Externally Calibrated
 - ① Preference, Production, Migration Parameters: $\{\varphi, \alpha, \beta, \theta, \xi, \rho\}$
 - ② Coupon Compensation, Wage Gap, Floor Area Ratio: $\{\kappa, \bar{h}, \eta\}$
 - ③ Land, Population, Prices (data): $\{\delta_n^f, \delta_n^h, \bar{N}_n, \bar{N}_u, \bar{N}_o, p_{ag}, p_{na}, w_o, r_o\}$
 - ④ Urban development (from observed 2015 prices): $\{c_u^B, \psi_u, B_{u,H}^0, \bar{D}_u^O\}$
- **Internally Calibrated** (matched to county- and aggregate-level moments) Internally Calibrated
 - ① Unobserved Productivities: $\{A_n^{ag}, A_u^{na}\}$
 - ② Unobserved Migration Costs: $\{\mu_{nu}, \mu_{no}\}$ and $\{\mu_{uo}^U, \mu_{ou}^U\}$
 - ③ Coupon Realization Probability b ; Developer wedge τ

The model is calibrated to a snapshot of data in 2015.

Calibration II: Internally Calibrated Parameters

Algorithm: given (r_u, τ, b) the 32 county blocks are **separable** and solved jointly

- **Inner:** for each county n , a 4×4 system in $(q_n, A_n^{ag}, \mu_{nu}, \mu_{no})$
- **Outer:** 3 aggregate conditions in (r_u, τ, b) — housing market, coupon market, aggregate coupon target

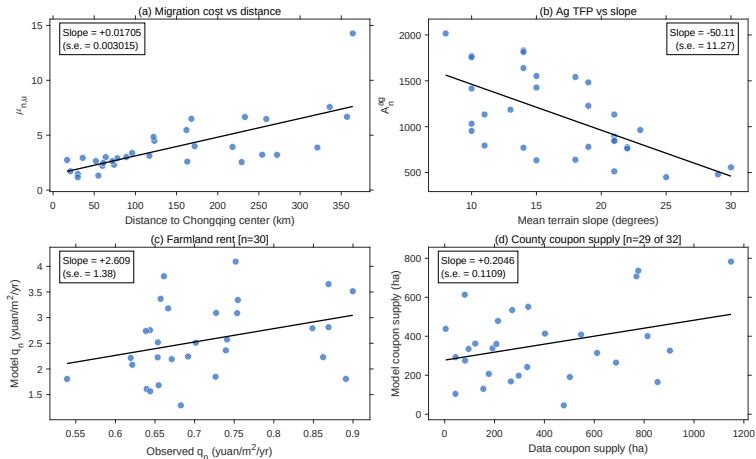
Just-identified system (# parameters = # moments = 101)

Parameter	Identifying moment	#
A_n^{ag}	County ag output value $p_{ag} Y_n^{ag}$	32
μ_{nu}	Migration share $n \rightarrow$ Chongqing urban	32
μ_{no}	Migration share $n \rightarrow$ outside	32
A_u^{na}	Chongqing urban wage (62,901 yuan/yr)	1
b	Aggregate coupon supply (11,405 ha)	1
μ_{uo}^U	Share of CQ-born living outside (0.1382)	1
μ_{ou}^U	Share of outside-born living in CQ (0.00138)	1
τ	Observed coupon price (300 yuan/m ²)	1

Calibrated: $b = 0.163$, $\tau = 323$ yuan/m² (2.6% of revenue, 9.0% of the land price).

Model Validation: Untargeted Moments

Model validation: untargeted moments



Counterfactuals

Baseline: calibrated economy with the land coupon market in 2015.

① No Coupon Market

- Shut down the land coupon market
- Rural residential land can no longer generate urban land quota

② Unlimited Urban Land

- Remove the urban development-capacity constraint
- Serves as the unconstrained urban-land benchmark

Counterfactual Results

Outcome	Baseline	CF1		CF2	
		No Coupon Market		Unlimited Urban Land	
		Level	Level	$\Delta\%$	Level
<i>Panel A. Migration shares (share of rural-born population)</i>					
Total	0.614	0.610	−0.58	0.614	+0.04
To Chongqing urban	0.369	0.363	−1.58	0.370	+0.20
Outside Chongqing	0.244	0.247	+0.94	0.244	−0.19
<i>Panel B. Agriculture</i>					
Ag. labor productivity (baseline = 1)	1.000	0.994	−0.59	0.998	−0.24
Farmland (1,000 ha)	1,663.6	1,652.2	−0.69	1,648.2	−0.93
<i>Panel C. Urban land market</i>					
Urban rent (yuan/m ² /yr)	207.1	238.5	+15.13	202.6	−2.22
Residential land (1,000 ha)	25.0	21.5	−14.00	25.6	+2.32
<i>Panel D. Shadow price of the urban land quota</i>					
λ_u (yuan/m ² , capital value)	300	2,336	+678.5	0	−100.0

Where Do the Agricultural Labor Productivity Gains Come From?

	Baseline	CF1 (No coupon)	Change
Rural-to-urban migration (millions)	9.39	9.34	−0.054
Rural stayers (millions)	5.92	5.97	+0.054
Ag. labor productivity (yuan/worker/yr)	19,064	18,953	−111
Total ag. output (bn yuan)	112.8	113.2	+0.4

- Without coupons, **54,000 more workers remain in farming**
- Average agricultural labor productivity falls by 111 yuan per worker per year
- Output rises mechanically because more workers remain in agriculture

Conclusion

Main takeaway: A market for rural residential land can support structural change under food-security constraints.

The Chongqing land coupon reform:

- links rural and urban land markets through a market-based mechanism
- relaxes urban land constraints, expanding urban land supply and lowering urban rent
- induces less productive farmers to leave agriculture and reallocates farmland toward remaining farmers, raising agricultural labor productivity

Rural residential land matters for economic development.

Thank you for listening !

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Backup Slides and References

Visiting Chongqing



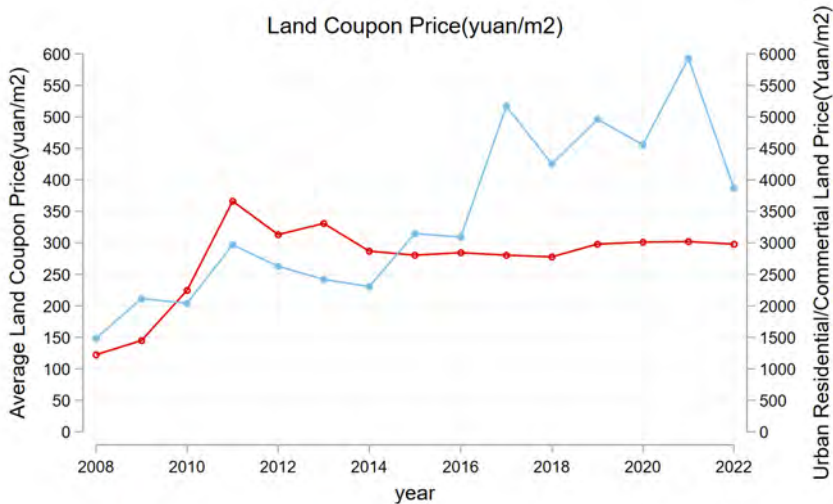
Characteristics of coupon suppliers

Table: Characteristics of Land Coupon Suppliers

Descriptive Statistics					
VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Area of reclaimed land (m ²)	474,047	301.6	188.3	10	1,136
Compensation (Yuan)	474,047	62,236	39,560	2,157	242,943
Gender (female=1)	99,489	0.168	0.374	0	1
Birth year	422,416	1,959	13.02	1,927	1,991

Note: This table reports basic characteristics of suppliers of land coupon. Data are from 2012–2024 compensation for land coupon sales.

Coupon Price



Farm Output and Profit

- Optimal farm size and output

$$s_n^f(z_n^{ag})^\star = \left(\frac{\beta p_{ag}}{q_n}\right)^{\frac{1}{1-\beta}} A_n^{ag} z_n^{ag}, \quad y_n^{ag}(z_n^{ag})^\star = \left(\frac{\beta p_{ag}}{q_n}\right)^{\frac{\beta}{1-\beta}} A_n^{ag} z_n^{ag} \quad (5)$$

- Farm profit

$$\pi_n^{ag}(z_n^{ag})^\star = (1 - \beta) \left(\frac{\beta}{q_n}\right)^{\frac{\beta}{1-\beta}} (p_{ag})^{\frac{1}{1-\beta}} A_n^{ag} z_n^{ag} + q_n \delta_n^f \quad (6)$$

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Developer's Optimal Decision: All Regimes

Let $M_u \equiv \eta(r_u - c_u^B) - \tau$ and $MC_B \equiv p_u^L(B_{u,H}^0) = \psi_u(B_{u,H}^0)^{1/\xi}$.

- Piecewise solution:**

$$x_u^\star = \begin{cases} 0, & M_u \leq 0 \\ (M_u/\psi_u)^\xi, & 0 < M_u \leq MC_B \quad (\text{capacity slack}) \\ B_{u,H}^0, & MC_B < M_u \leq MC_B + t \quad (\text{corner}) \\ ((M_u - t)/\psi_u)^\xi, & M_u > MC_B + t \quad (\text{positive coupon}) \end{cases}$$

- Coupon demand $D_u^{H,\star} = \max\{0, x_u^\star - B_{u,H}^0\}$; floor supply $H_u^\star = \eta x_u^\star$
- Shadow price of the capacity constraint: $\lambda_u = t$ in the positive-coupon regime
- At the calibrated baseline:** regime 4, with $x_u^\star = 25,001$ ha $> B_{u,H}^0 = 21,502$ ha and $\lambda_u = t = 300$ yuan/m²

Wage Per Effective Unit of Labor in Na Sector

- $\bar{h} \geq 1$ captures the efficiency gap between urban-origin workers and rural-to-urban migrants (migrants have na ability = 1)
- Profit maximization of the representative firm

$$\max_{\{L_u^{na}\}} \pi(L_u^{na}) = p_{na} A_u^{na} L_u^{na} - w_u^{na} L_u^{na} \quad (7)$$

$$L_u^{na} = \sum_n m_{nu} \bar{N}_n + \bar{h} N_u^U, \quad N_u^U = \bar{N}_u m_{uu}^U + \bar{N}_o m_{ou}^U$$

- Wage per efficient labor unit:

$$w_u^{na} = p_{na} A_u^{na} \quad (8)$$

- labor income of urban-origin workers: $p_{na} A_u^{na} \bar{h}$
 - labor income of rural-to-urban migrants: $p_{na} A_u^{na}$
- **Calibration:** A_u^{na} is set so that $w_u^{na} = p_{na} A_u^{na}$ matches the observed 2015 Chongqing urban wage of 62,901 yuan/year

Urban-Origin Residents

- Urban-origin workers born in $k \in \{u, o\}$ have **no land endowment** and supply $\bar{h}$ efficiency units; **they choose between Chongqing (u) and the outside city (o)**
- Indirect utility from destination $m \in \{u, o\}$:

$$\bar{V}_{km}^U = c_2 \frac{\bar{h} w_m}{(p_{ag})^{\alpha\varphi} (p_{na})^{\alpha(1-\varphi)} (r_m)^{1-\alpha} \mu_{km}^U}, \quad \mu_{uu}^U = \mu_{oo}^U = 1$$

- Destination shares: $m_{km}^U = \frac{(\bar{V}_{km}^U)^\rho}{(\bar{V}_{ku}^U)^\rho + (\bar{V}_{ko}^U)^\rho}, \quad m_{ku}^U + m_{ko}^U = 1$
- Urban-origin residents living in Chongqing:

$$N_u^U = \bar{N}_u m_{uu}^U + \bar{N}_o m_{ou}^U$$

- Optimal consumption (income $I = \bar{h} w_m$): $c^{ag} = \frac{\alpha\varphi I}{p_{ag}}, \quad c^{na} = \frac{\alpha(1-\varphi)I}{p_{na}}, \quad h = \frac{(1-\alpha)I}{r_m}$
- Calibration:** μ_{uo}^U, μ_{ou}^U match the observed shares $m_{uo}^U = 0.1382$ and $m_{ou}^U = 0.00138$

Indirect utility of Rural Stayers

- Rural stayer i with endowments (δ_n^f, δ_n^h) chooses coupon supply $s_n^{coupon}(i) \in [0, \delta_n^h]$
- Coupon trade is risky:** with probability $b \in (0, 1)$, the trade succeeds
 - ✓ **Success (prob. b):** residential land $\rightarrow$ farmland; farmer receives coupon revenue κt per unit
 - Farmland becomes $\delta_n^f + s_n^{coupon}(i)$, Residential land becomes $\delta_n^h - s_n^{coupon}(i)$
 - **Farmer's share of coupon revenue** $\kappa \in (0, 1)$
 - ✗ **Failure (prob. $1 - b$):** no conversion, no coupon compensation; endowments unchanged
- Indirect utility of Rural Stayers**

$$V_{nn}(i) = \left[b \cdot c_1 \cdot \frac{[\pi_{n0}(i) + (q_n + \kappa t) s_n^{coupon}(i)]^\alpha [\delta_n^h - s_n^{coupon}(i)]^{1-\alpha}}{(p_{ag})^{\alpha\varphi} (p_{na})^{\alpha(1-\varphi)}} + (1 - b) \cdot c_1 \cdot \frac{[\pi_{n0}(i)]^\alpha [\delta_n^h]^{1-\alpha}}{(p_{ag})^{\alpha\varphi} (p_{na})^{\alpha(1-\varphi)}} \right] \cdot \epsilon_{nn}(i)$$

Where $c_1 \equiv \varphi^{\alpha\varphi} (1 - \varphi)^{\alpha(1-\varphi)}$; $\pi_{n0}(z) \equiv (1 - \beta) \left(\frac{\beta}{q_n} \right)^{\frac{\beta}{1-\beta}} (p_{ag})^{\frac{1}{1-\beta}} A_n^{ag} z + q_n \delta_n^f$

Optimal Coupon Supply of Rural Stayers

- **Optimal coupon supply:**

$$s_n^{coupon}(z)^{\star} = \max \left\{ 0, \alpha \delta_n^h - \frac{(1-\alpha)\pi_{n0}(z)}{q_n + \kappa t} \right\} \quad (9)$$

- **Cutoff productivity:** rural stayers supply coupon iff $z_n^{ag}(i) \leq \bar{z}_{n0}$, where

$$\bar{z}_{n0} \equiv \frac{\alpha(q_n + \kappa t)\delta_n^h - (1-\alpha)q_n\delta_n^f}{(1-\alpha)(1-\beta)\left(\frac{\beta}{q_n}\right)^{\frac{\beta}{1-\beta}}(p_{ag})^{\frac{1}{1-\beta}}A_n^{ag}} \quad (10)$$

- **Indirect utility of rural stayers:** $V_{nn}(i) = \bar{V}_{nn}(z) \cdot \epsilon_{nn}(i)$

$$\bar{V}_{nn}(z) = \begin{cases} b \cdot c_2 \frac{\pi_{n0}(z) + (q_n + \kappa t)\delta_n^h}{(p_{ag})^{\alpha\varphi}(p_{na})^{\alpha(1-\varphi)}(q_n + \kappa t)^{1-\alpha}} + (1-b) \cdot c_1 \frac{\pi_{n0}(z)^{\alpha}(\delta_n^h)^{1-\alpha}}{(p_{ag})^{\alpha\varphi}(p_{na})^{\alpha(1-\varphi)}}, & z \leq \bar{z}_{n0} \\ c_1 \frac{\pi_{n0}(z)^{\alpha}(\delta_n^h)^{1-\alpha}}{(p_{ag})^{\alpha\varphi}(p_{na})^{\alpha(1-\varphi)}}, & z > \bar{z}_{n0} \end{cases} \quad (11)$$

where $c_2 \equiv \alpha^{\alpha}(1-\alpha)^{1-\alpha}\varphi^{\alpha\varphi}(1-\varphi)^{\alpha(1-\varphi)}$

Indirect Utility of Migrants

- A migrant from rural origin n chooses destination $m \in \{u, o\}$, where u denotes Chongqing urban area and o denotes the outside-option city.
- With probability b , the migrant converts residential land into a coupon; with probability $1 - b$, the migrant keeps the residential land.

- **Indirect utility:**

$$V_{nm}(i) = \bar{V}_{nm} \cdot \epsilon_{nm}(i) \quad (12)$$

$$\bar{V}_{nm} = c_2 \frac{b \cdot I_{nm}^1(i) + (1 - b) \cdot I_{nm}^0(i)}{(p_{ag})^{\alpha\varphi} (p_{na})^{\alpha(1-\varphi)} (r_m)^{1-\alpha} \mu_{nm}}$$

- **Nominal income:**

$$\blacksquare \quad I_{nm}^1(i) = \underbrace{p_{na}A_m^{na}}_{\text{urban wage}} + \underbrace{q_n\delta_n^f}_{\text{farmland rent}} + \underbrace{(q_n + \kappa t)\delta_n^h}_{\text{coupon revenue}}, \quad I_{nm}^0(i) = p_{na}A_m^{na} + q_n\delta_n^f$$

Migration Decision and Migration Share

- Individual i with farming ability z_n^{ag} migrates to the city iff:

$$\max_{m \in \{u, o\}} \{ \bar{V}_{nm} \epsilon_{nm}(i) \} \geq \bar{V}_{nn}(z) \epsilon_{nn}(i)$$

- Conditional migration probability** ($m \in \{u, o\}$):

$$p_{nm}(z) = \frac{\bar{V}_{nm}^\rho}{\bar{V}_{nn}(z)^\rho + \bar{V}_{nu}^\rho + \bar{V}_{no}^\rho}, \quad p_{n,mig}(z) = \frac{\bar{V}_{nu}^\rho + \bar{V}_{no}^\rho}{\bar{V}_{nn}(z)^\rho + \bar{V}_{nu}^\rho + \bar{V}_{no}^\rho}$$

- Migration share** ($m \in \{u, o\}$):

$$m_{nm} = \int_0^\infty p_{nm}(z) dF(z) \quad (13)$$

Farmland Market Clearing

- Farmland market clearing:**

$$\underbrace{\bar{N}_n \delta_n^f}_{\text{initial farmland}} + \underbrace{b \bar{N}_n \left[\delta_n^h \int_0^\infty p_{n,mig}(z) dF(z) + \int_0^{\bar{z}_{n0}} s_n^{coupon}(z)^\star (1 - p_{n,mig}(z)) dF(z) \right]}_{\text{farmland from rural housing conversion}}$$

$$= \underbrace{\bar{N}_n \int_0^\infty s_n^f(z)^\star (1 - p_{n,mig}(z)) dF(z)}_{\text{farmland demand by rural stayers}} .$$
(14)

- where $s_n^f(z)^\star = \left(\frac{\beta p_{ag}}{q_n} \right)^{\frac{1}{1-\beta}} A_n^{ag} z$

Urban Land Market Clearing

- Urban floor-space market clearing:

$$\underbrace{\eta \left[\frac{\eta(r_u - c_u^B) - \tau - t}{\psi_u} \right]^\xi}_{\text{supply by developer}} = \underbrace{\frac{(1 - \alpha) \bar{h} w_u}{r_u} N_u^U}_{\text{demand by urban-origin residents}} + \underbrace{\sum_{n=1}^N \frac{(1 - \alpha) \left[w_u + q_n \delta_n^f + b(q_n + \kappa t) \delta_n^h \right]}{r_u} m_{nu} \bar{N}_n}_{\text{demand by rural-origin migrants}} \quad (15)$$

- $N_u^U = \bar{N}_u m_{uu}^U + \bar{N}_o m_{ou}^U$ is **endogenous**: urban-origin residents choose between Chongqing and the outside city
- $w_u = p_{na} A_u^{na}$

Coupon Market Clearing

- **Aggregate coupon market clearing:**

$$\underbrace{\sum_{n=1}^N b\bar{N}_n \left[\delta_n^h \int_0^\infty p_{n,mig}(z) dF(z) + \int_0^{\bar{z}_{n0}} s_n^{coupon}(z)^\star (1 - p_{n,mig}(z)) dF(z) \right]}_{\text{coupon supply: migrants + rural stayers}} = \underbrace{D_u^{H,\star}}_{\text{residential}} + \underbrace{\bar{D}_u^O}_{\text{non-residential}} \quad (16)$$

- $D_u^{H,\star} = x_u^\star - B_{u,H}^0$: residential coupon demand (share $\lambda_H = 0.3068$ of observed transactions)
- $\bar{D}_u^O = 7,906$ ha: coupon demand from commercial and other non-residential uses, **exogenous and perfectly inelastic**
- **At the calibrated baseline, 99.7% of coupon supply comes from migrants' idle homesteads:** the stayer cutoff $\bar{z}_{n0}$ binds for almost no one

Competitive Equilibrium

- A **competitive equilibrium** is a set of prices $\{w_u^{na}, q_n, r_u, t\}$, consumption bundles $\{c_{nm}^{ag}(i), c_{nm}^{na}(i), s_{nm}^h(i)\}$, farmer's farmland and output decisions $\{s_n^f(i), y_n^{ag}(i)\}$, migration flows $\{m_{nu}, m_{no}\}$, labor inputs and output in the non-ag. sector $\{L_u^{na}, Y_u^{na}\}$, urban residential land supply $\{S_u^h\}$, land coupon supply $\{S_n^{coupon}\}$ and demand $\{D_u^{coupon}\}$, such that:
 - (i) given prices and endowments, $\{c_{nm}^{ag}(i), c_{nm}^{na}(i), s_{nm}^h(i)\}$ solves the **farmer's utility maximization** problem subject to the budget constraint [Eq. (1)]
 - (ii) given prices and endowments, $\{s_n^f(i), y_n^{ag}(i)\}$ solves the **farmer's profit maximization** problem [Eq. (2), with optimal $s_n^f(i)^*$ and $y_n^{ag}(i)^*$ in Eq. (5)]

Competitive Equilibrium (cont'd)

- ... such that:
 - (iii) given prices, $\{L_u^{na}, Y_u^{na}\}$ solves the representative firm's **profit maximization** problem in the non-ag. sector [Eq. (3)]
 - (iv) given prices, $\{H_u^*, D_u^{coupon,*}\}$ (and hence $S_u^h = H_u^*/\eta$) solves the representative **developer's profit maximization** problem [Eq. (4)]
 - (v) given prices and endowments, each individual makes
 - ▶ the **migration decision** $\{m_{nu}, m_{no}\}$ [Eq. (13)]
 - ▶ the **coupon participation decision** $s_n^{coupon}(i)^*$ [Eq. (9)], with cutoff productivity $\bar{z}_{n0}$ [Eq. (10)]
 - (vi) **markets clear**:
 - ▶ farmland market in each rural region n [Eq. (14)]
 - ▶ urban floor-space market in Chongqing [Eq. (15)]
 - ▶ land coupon market [Eq. (16)]
 - ▶ non-ag. labor market: $w_u^{na} = p_{na}A_u^{na}$ [Eq. (8)]

Aggregate Agricultural Output and Labor Productivity

- Aggregate ag output in n

$$\begin{aligned}
 Y_n^{ag} &\equiv \bar{N}_n \int_0^\infty y_n^{ag}(z)^* (1 - p_{n,mig}(z)) dF(z) \\
 &= \bar{N}_n (1 - m_n) \left(\frac{\beta p_{ag}}{q_n} \right)^{\frac{\beta}{1-\beta}} A_n^{ag} E[z|stay]
 \end{aligned} \tag{17}$$

- Aggregate labor productivity in n

$$LP_n^{ag} \equiv \frac{Y_n^{ag}}{\bar{N}_n (1 - m_n)} = \left(\frac{\beta p_{ag}}{q_n} \right)^{\frac{\beta}{1-\beta}} A_n^{ag} E[z|stay] \tag{18}$$

Calibration I: Externally Calibrated Parameters

Item	Description	Value	Source/Method
<i>Parameters from Literature</i>			
φ	Ag. consumption share	0.095	Tombe and Zhu (2019)
α	Expenditure share of goods	0.87	Tombe and Zhu (2019)
β	Land share in ag. production	0.36	Adamopoulos et al. (2022)
θ	Ability dispersion	5.3	Lagakos and Waugh (2013)
ξ	Land supply elasticity	3.2	Yu (2026)
ρ	Migration elasticity	1.5	Tombe and Zhu (2019)
<i>Exogenous variables and data source</i>			
κ	Coupon compensation share to farmers	0.7	Coupon transaction
$\bar{h}$	Urban–migrant wage gap	1.15	Population Census in 2005
η	Floor area ratio	2.5	Urban Land Plot Transaction in Chongqing
δ_n^f, δ_n^h	Farmer land endowment	Data	Land Survey and coupon transactions
N_n, N_u	Regional working-age population	Data	Chongqing statistical yearbook
λ_H	Residential share of coupon purchases	0.3068	Coupon purchaser industry (area-wtd)
c_u^B	Annualized construction cost	136.40	$3255/\Lambda, \Lambda = P_{u,0}^H/r_{u,0}^{data} = 23.86$
ψ_u	Urban land-development cost	0.3580	$p_{u,0}^L/x_{u,0}^{1/\xi}, p_{u,0}^L = 150.73$
$B_{u,H}^0$	Residential land available w/o coupons	21,502 ha	$x_{u,0} - \lambda_H C_0$
$\bar{D}_u^O$	Non-residential coupon demand	7,906 ha	$(1 - \lambda_H) C_0$
w_o, r_o	Outside wage and housing rent	Data	City Yearbook; CFPS
p_{ag}, p_{na}	Goods prices	Data	Following Gai et al. (2025)

Calibration Overview

Model Fit

- **Targeted moments** ($101 = 101$, just identified)
 - County ag output value $p_{ag}Y_n^{ag}$; county migration shares m_{nu}, m_{no}
 - Chongqing urban wage $w_u = 62,901$; aggregate coupon supply 11,405 ha
 - Urban-origin location shares m_{uo}^U, m_{ou}^U
 - Observed coupon price $t_0 = 300$ yuan/m² (identifies the wedge τ)
- **Untargeted moments** (*validation*)
 - **Urban housing rent:** model 207.1 vs. CFPS 210.05 (−1.4%)
 - **Geography** (not in calibration)
 - Migration cost $\mu_{n,u}$ vs. distance to Chongqing (corr +0.72)
 - Ag TFP A_n^{ag} vs. terrain slope (corr −0.63)
 - **External data** (not in calibration)
 - Farmland rental rate q_n vs. observed rents (*Tuliu*), $n = 30$
 - County coupon supply vs. transaction data, $n = 29$
 - Aggregate non-ag output value $p_{na}Y_u^{na}$

Calibration of p_a and p_{na}

- Following Gai et al. (2025) I construct price index p_a and p_{na}
- ① Construct prices for the benchmark year 2005 using data from GGDC productivity level database

$$p_{a,2005}^{GGDC} = p_{1,2005}^{GGDC}$$

$$p_{na,2005}^{GGDC} = \frac{\text{National Price Non-ag Value-added in Year 2005}}{\sum_{i=2}^{10} \left(\text{National Price Value-added of Sector } i \text{ and Year 2005} / p_{i,2005}^{GGDC} \right)}$$

- ② Obtain sector-specific GDP deflator from NBS with the year 2005 normalized to one
- ③ Sector prices are

$$p_{j,2015} = p_{j,2005}^{GGDC} * \text{Price of US GDP in 2005} * E_{2005} * \text{deflator}_{2015}$$

- E_{2005} : China-US nominal exchange rate
- $\bar{p}$ = Price of US GDP in 2005 * E_{2005}
- Following Gai et al. (2025), $\bar{p} = 16.312$
- price index in 2015: $p_{ag} = 11.252$, $p_{na} = 7.482$

Outside Urban Region

- Rural-to-urban migration weights from 2000 population census
- Weighted average wage in 2015: 64937 yuan per year
 - Chongqing: 62901
 - Data source: City Statistic Yearbook
- Weighted average housing rent: 270.95 yuan/m²/year
 - Chongqing: 210.05 yuan/m²/year
 - Data source: CFPS

Other Data in Chongqing

- Total coupon supply (2008–2015): **11,405** ha
 - residential $\lambda_H C_0 = 3,499$ ha; non-residential 7,906 ha
- Chongqing urban wage 2015: **62,901** yuan/yr (calibration target)
- Na output value ($p_{na} Y_u^{na}$): 145671200 wanyuan (untargeted)
- Urban-origin working population: $\bar{N}_u = 9,393,631$
- **Urban price inputs (2015, capital values, yuan/m²):**
 - housing sale price $P_{u,0}^H = 5,012.45$; housing rent $r_{u,0}^{data} = 210.05/\text{yr}$
 - construction cost $c_u^{B,K} = 3,255$; residential land price $p_{u,0}^{L,K} = 3,597$
 - observed coupon price $t_0^K = 300$; capitalization factor $\Lambda = 23.86$ (gross yield 4.19%)
- Urban housing stock 2015: 18.38m urban residents $\times 34.0 \text{ m}^2 \Rightarrow x_{u,0} = 25,001$ ha at $\eta = 2.5$