Bridging Quasi-natural Experiments and Structural Models

Rural Pensions, Labor Reallocation, and Aggregate Income: An Empirical and Quantitative Analysis of China

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Agricultural Productivity Gap (APG)

- In developing countries, there exists an observed gap in the labor productivity/earnings between the agricultural and non-agricultural sectors, even after accounting for sectoral differences in observable worker characteristics.
  - Vollrath (2009), Gollin, Lagakos, and Waugh (2014)
- A large share of the labor force remains in agriculture, resulting in significant lags in aggregate productivity.
  - Gollin, Parente, and Rogerson (2002), Caselli (2005), Restuccia, Yang, and Zhu (2008)

Research Questions

- What are the sources of observed sectoral labor productivity gaps?
- Why do developing countries fail to reallocate labor from the agricultural sector to the non-agricultural sector?
- Are there policies that can improve labor allocation and increase aggregate productivity and income?

Recent Debate on APG

1. Unobservable skills and sorting across sectors
   - Beegle et al. (2011); Lagakos and Waugh (2013); Young (2013); Herrendorf and Schoellman (2018); Alvarez (2020); Harmory et al. (2021)
2. Underlying sectoral productivity difference & mobility barriers
   - Restuccia et al. (2008); Bryan et al. (2014); Munshi and Rosenzweig (2016); Lagakos et al. (2018); Ngai et al. (2019); Tombe and Zhu (2019); Lagakos et al. (2020)
3. A combination of both
   - Lagakos (2020) and Donovan and Schoellman (2020)

- We use a unique large panel dataset and a policy experiment in China to identify APG and migration costs.

Policy and Data

- Policy: New Rural Pension Scheme (NRPS) was rolled out across all rural counties between 2009 and 2012.
  - Elderly aged above 60 are eligible for receiving pension benefits.
  - Reduce the labor supply of the elderly and increase the labor supply of young adults in the same family
  - Reduce the migration costs of young workers in households with pension-eligible family members.
- Data: annual National Fixed Point Survey of Agriculture (NFP) from 2003 to 2013
  - A large panel dataset that tracks 80,000 agricultural workers and rural-to-urban migrants

What We Do

- Reduced-form estimation of labor productivity gains from rural-urban migration in China that carefully controls for sorting/selection
  - Use the pension reform in rural China as an IV for migration: the county-by-county rollout interacting with the presence of pension-eligible elderly household members
- Structural estimation of a household decision model with household production in agriculture, endogenous labor supply, and labor sorting across sectors
  - A non-cooperative game between rural youth and elderly with shared home production
- Counterfactual analysis based on the estimated GE model

Preview of Results (1)

Reduced form estimation:

- First stage: NRPS increases migration by 4.2 percentage points for young workers from households with pension-eligible elderly members.
- LATE estimate: 86 log points
  - Average migration cost for marginal workers is around 86% of potential non-agricultural earnings.
- OLS and ATE (control function approach): 31 and 33 log points
  - Sorting plays a minor role.
- The pension reform decreases the labor supply of the elderly but increases the labor supply of young adults.

Preview of Results (2)

Structural estimation:

- High migration costs are the main reason for the large observed APG.

Counterfactual analysis:

- The NRPS: migrants' labor supply $\uparrow$ 6%, that of the elderly $\downarrow$ 34%, GDP $\uparrow$ 2.4%, welfare $\uparrow$ 15%.
- Scaling up the reform by raising the pension transfer amount fivefold: GDP $\uparrow$ 4.2%, welfare $\uparrow$ 28.5%.
- A *hukou* policy reform: migration rate $\uparrow$ 2.8 ppt, GDP $\uparrow$ 2.0%. Sectoral labor reallocation vs. within household labor reallocation.
- The combination of the NRPS and actual *hukou* reforms between 2003 and 2013: migration rate $\uparrow$ 6.5 ppt, GDP $\uparrow$ 6.6%.

Contribution

- Impact of pension transfers
  - Elderly: Jensen, 2004; de Carvalho, 2008; Huang and Zhang 2021
  - Intra-household arrangements: Bertrand et al, 2003; Duflo, 2003; Ardinton et al., 2009; Eggleston et al. 2018; Guo et al. 2023
  - We introduce a structural model that can interpret the empirical results and quantify the aggregate effects of rural pensions.
- Understanding the observed APG
  - General equilibrium Roy models: Lagakos and Waugh, 2013; Tombe and Zhu, 2019; Hao et al., 2020
  - Individual fixed effect regressions: Herrendorf and Schoellman, 2018; Alvarez, 2020; Lagakos et al., 2020; Hamory et al., 2021
  - We exploit a quasi-natural experiment as an instrument to estimate LATE and ATE.
- Measure migration costs
  - Macro structural approach: Restuccia, Yang and Zhu, 2008; Tombe and Zhu, 2019; Bryan and Morten, 2019; Hao et al., 2020
  - Micro reduced-form approach: Lagakos et al., 2018; Bryan, Chowdhury and Mobarak, 2014; Cai, 2020; Imbert and Papp, 2020
  - We combine the two in an integrated framework and open up the black box of migration costs with a pension reform.

Data and Institutional Background: NFP

- The National Fixed Point Survey (NFP)

  More

  - An origin-based annual panel survey collected by the Chinese Ministry of Agriculture.
  - It surveys around 20,000 households and 80,000 individuals from 350 villages in 31 provinces per year during 2003-2013.

	Raw Data		Our Sample	
Years	Observations	Share(%)	Observations	Share(%)
1	56,185	28.46		
2	29,227	14.81	12,039	24.67
3	19,093	9.67	8,771	17.97
4	16,015	8.11	6,576	13.48
5	11,442	5.80	5,134	10.52
6	10,445	5.29	4,251	8.71
7	8,778	4.45	3,464	7.10
8	8,333	4.22	3,020	6.19
9	8,127	4.12	2,728	5.59
10	12,297	6.23	1,978	4.05
11	17,449	8.84	840	1.72
Total	197,390	100	48,801	100

- In the raw data, 57% observations can be traced $\geq$ 3 years.
- Restrict our sample to adults (20-54) without college degree, and can be observed for at least 2 years.
- Migration: working more than 180 days out of town.

Table: Summary Statistics

Sample:	All	NonAgri	Agri
ln Daily wage	3.5084	3.6949	3.4275
	(0.9025)	(0.6993)	(0.9665)
ln Annual income	8.8450	9.3842	8.6110
	(1.0095)	(0.6860)	(1.0373)
Total working days	236.6606	302.2150	208.2063
	(99.3144)	(44.2010)	(103.0613)
Share of working days in:			
Within-town Agri production	0.5548	0.0356	0.7802
	(0.4343)	(0.0770)	(0.3164)
Within-town NonAgri production	0.1221	0.0049	0.1729
	(0.2567)	(0.0285)	(0.2926)
Out-of-town	0.3231	0.9595	0.0469
	(0.4434)	(0.0844)	(0.1636)
Age	38.4856	32.1853	41.2203
	(10.3787)	(9.0924)	(9.6892)
Years of Schooling	7.1940	8.1015	6.8001
	(2.4455)	(2.0354)	(2.5029)
Female	0.4701	0.3303	0.5307
	(0.4991)	(0.4703)	(0.4991)
Poor health status	0.0121	0.0035	0.0159
	(0.1094)	(0.0592)	(0.1249)
Household with an elderly aged $\geq$60	0.2797	0.3505	0.2489
	(0.4488)	(0.4771)	(0.4324)
Number of observations	229,849	69,570	160,279
Share of workers	1.000	0.3027	0.6973

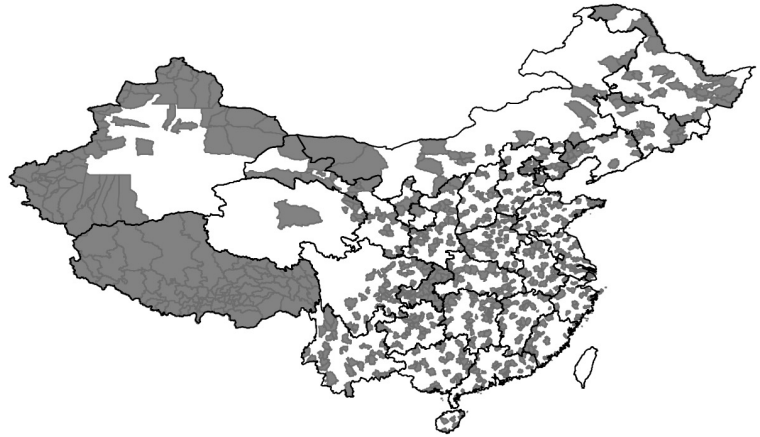
Notes: Standard deviation in parentheses.

Data and Institutional Background: NRPS

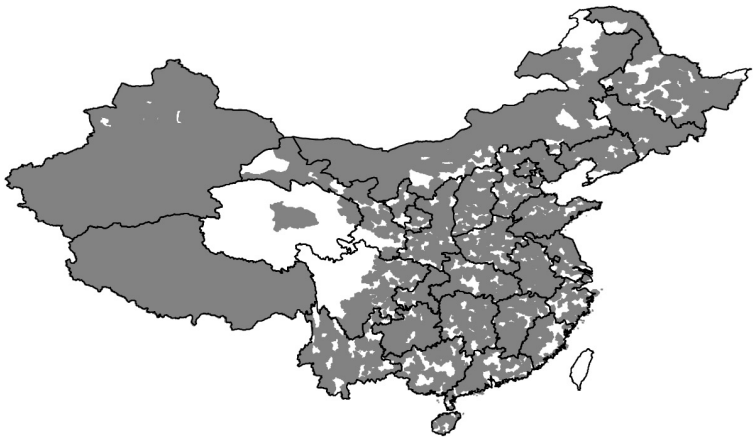
The New Rural Pension Scheme (NRPS):

- Individuals aged 60 or older are eligible to receive the basic pension benefit of 660 RMB (around 108 USD) per year, 68% of their income.
- A staggered rollout across the country during 2009-2012.
- The pension benefit in effect lowers the migration costs of the younger household members through a home production channel.
  - Eldercare: Eggleston et al., 2018; Cheng et al., 2018; Li et al., 2018; Guo et al., 2023
  - Childcare: Jiao, 2016; Li et al., 2018
- However, it shouldn't change younger household members' innate abilities.

(a) First round: Nov 2009



(b) Second round: July–Oct 2010



(c) Third round: July–Sep 2011

(d) Fourth round: July–Oct 2012

Figure: County-by-county Rollout of the NRPS over Time

Reduced Form Analysis

Productivity Differences, Migration Costs and Sorting

- Underlying nominal labor productivity difference between the agricultural and non-agricultural sectors (*underlying APG*):

$$R = \ln\left(w_{na}/w_a\right).$$

- The observed log daily earnings is

$$\ln y_{ihat} = \ln w_a + X\beta + U_a$$
$$\ln y_{ihnat} = \ln w_a + R + X\beta + U_{na}$$

- We obtain observed average labor productivity difference (*observed APG*) obtained from OLS estimation

$$\ln y_{ihjt} = \gamma_1 NonAgri_{ihjt} + X_{ihjt}\gamma_2 + \varphi_j + \varphi_{pt} + \nu_{ihjt},$$

- The OLS estimate is biased due to selection in comparative advantage:

$$R_{\text{OLS}} = R + E[U_{na}|V < R - M(\boldsymbol{X}, \boldsymbol{Z})] - E[U_a|V \geq R - M(\boldsymbol{X}, \boldsymbol{Z})]$$

where $V = U_{na} - U_a$ and $M(X, Z)$ is the migration cost.

Table: Sector of Employment and Daily Wage: OLS v.s. Individual FE

Dep. Var.: ln Daily Wage	(1) OLS	(2) FE
NonAgri	0.3059***	0.3669***
	(0.0141)	(0.0156)
Individual controls	Y	Y
Province× Year FE	Y	Y
Village FE	Y	N
Individual FE	N	Y
Observations	229,849	229,847
R-squared	0.4174	0.6661

▸ Annual Income

Individual Fixed Effects

- Individual FE estimate is very close to the OLS estimate.
- Different from the findings in Herrendorf and Schoellman (2018), Alvarez (2020), and Hamory et al (2021), which show large reductions in returns to migration after controlling individual FE.
- Not surprising: migration costs are larger in China due to the *hukou* system
- Individual FE estimate is also subject to selection bias if there are heterogeneous comparative advantage that is correlated with migration
- Therefore, we need an instrument that affects migration, but not directly affect daily earnings of migrants

IV Estimation: DDD

The first-stage regression is

$$NonAgri_{ihjt} = \beta_1 Elder60_{hjt} \times NRPS_{jt} + X_{ihjt}\beta_2 + \varphi_j + \varphi_{pt} + \nu_{ihjt},$$

The second stage of the IV estimation is

$$\ln y_{ihjt} = \gamma_1 \widehat{NonAgri}_{ihjt} + X_{ihjt}\gamma_2 + \varphi_j + \varphi_{pt} + u_{ihjt},$$

- DDD strategy: address the concern the NRPS may have been rolled out endogenously across counties.
- LATE: an estimate of the average migration cost faced by the workers whose migration decisions are affected by the policy treatment.

Control Function Approach: ATE

- Include control functions to proxy for selection terms

$$E[U_a|\mathbf{1}(j=a), \boldsymbol{X}, \boldsymbol{Z}] \quad \text{and} \quad E[(U_{na})|\mathbf{1}(j=na), \boldsymbol{X}, \boldsymbol{Z}].$$

  in the estimating equation. R^{CF} captures ATE (i.e., R).

- With the assumption that U_a and U_{na} follow a joint normal distribution, we estimate the following regression (Card 2001):

$$\begin{aligned}\ln y_{ihjt} = {} & \gamma_1 NonAgri_{ihjt} + X_{ihjt}\gamma_2 \\ & + \gamma_3 NonAgri_{ihjt} \times \frac{\phi((Z_{ihjt}, W_{ihjt})\zeta)}{\Phi((Z_{ihjt}, W_{ihjt})\zeta)} \\ & + \gamma_4(1 - NonAgri_{ihjt}) \times \frac{\phi((Z_{ihjt}, W_{ihjt})\zeta)}{1 - \Phi((Z_{ihjt}, W_{ihjt})\zeta)} + \varphi_j + \varphi_{pt} + \omega_{ihjt}\end{aligned}$$

- More generally, we proxy for the selection terms by flexible functions of residuals from a first stage probit regression (Wooldridge, 2015).

Table: Sector of Employment and Daily Wage: IV and Control Function

Dep. Var.:	(1) NonAgri First Stage	(2) ln Daily Wage 2SLS	(3) ln Daily Wage CF
NonAgri		0.8614**	0.3261***
		(0.3532)	(0.0284)
Elder60 × NRPS	0.0418***		
	(0.0075)		
NRPS	0.0113	-0.0423	
	(0.0100)	(0.0304)	
Elder60	0.0232***	-0.0177	
	(0.0026)	(0.0119)	
NonAgri$\times\frac{\phi((Z,W)\hat{\zeta})}{\Phi((Z,W)\hat{\zeta})}$			-0.1358***
			(0.0180)
(1-NonAgri)$\times\frac{\phi((Z,W)\hat{\zeta})}{1-\Phi((Z,W)\hat{\zeta})}$			-0.1212***
			(0.0173)
Individual controls	Y	Y	Y
Province × Year FE	Y	Y	Y
Village FE	Y	Y	Y
Observations	229,849	229,849	229,236
R-squared	0.3611	–	0.4191
Kleibergen-Paap F-Stat	–	31.02	–

▸ Additional Results

Summary of Reduced-Form Results on Returns to Migration

- LATE (IV) estimate suggests large migration costs faced by workers who migrated as a result of NRPS (around 86% of non-ag earnings).
- ATE estimate is similar to OLS estimate (33 vs. 31 log points), suggesting a small sorting effect.
- The effect of NRPS on migration is larger among regions with stricter *hukou* policy, women (particularly those with children), less educated and older workers.

Mechanism: Why Does NRPS Affect Rural-Urban Migration?

- The NRPS provides income transfers to elder household members in the rural areas.
- The income effect is such that elderly members reduce labor supply and increase home production (e.g., childcare and eldercare).
- The increase of home production by elderly allows young members of rural households to reduce their own home production and increase labor supply, which increases the return to migration.

Table: Effects of the NRPS on the Labor Supply of the Elderly and Young Workers

Dep. Var.:	(1) ln(1+Working Days) Elder OLS	(2) Working Days Elder Poisson	(3) ln(1+Working Days) Youth OLS	(4) Working Days Youth Poisson
Elder60×NRPS			0.0354***	0.0145**
			(0.0099)	(0.0057)
NRPS	-0.0146*	-0.0904**	-0.0122	-0.0068
	(0.0077)	(0.0376)	(0.0186)	(0.0117)
Elder60			0.0010	0.0053**
			(0.0042)	(0.0026)
Individual controls	Y	Y	Y	Y
Province×Year FE	Y	Y	Y	Y
Village FE	Y	Y	Y	Y
Observations	41,064	40,996	219,305	219,305
R-squared	0.2767	–	0.2765	–

▸ Additional Evidence ▸ Omitted Channels?

Structural Model

Overview

A household decision model

- A Roy model to capture the unobserved Agr and NonAgr abilities
- A non-cooperative Nash game between parents and adult children
- Model migration, labor supply, and home production decisions
- Allow for diminishing return to labor in the agricultural sector

Preference and Time Allocation

- Each household has two groups of members, parents (o) and adult children (y).
- Three sectors: rural agricultural (a), rural non-agricultural (r), and urban non-agricultural (na)

$$l_o + k_o = n_o,$$

$$l_y + l_{na}\mathbf{1}_{\{d=na\}} + k_y = n_y$$

  - n_o and n_y: numbers of old and young, respectively.
  - l_o and l_y: total labor supply of old and young agents in the rural area.
  - l_{na}: labor supply of young agents in the urban non-agricultural sector.
  - d: migration decision of young agents.

Preference and Time Allocation

All members of a household have the same preferences:

$$\mathcal{U}_r = \frac{1}{1-\gamma}\left(c^r\right)^{1-\gamma} - \frac{\eta}{1+\frac{1}{\phi}}\frac{\left(\xi(n_o-k_o)+(n_y-k_y)\right)^{1+\frac{1}{\phi}}}{\left(n_o+n_y\right)^{(1+\frac{1}{\phi})}}.$$

- c^r: private consumption determined by a non-homothetic CES utility function
- ϕ: Frisch elasticity of labor supply
- $-\eta$: utility from home-produced goods/disutility of labor supply.
- ξ: household production efficiency of elderly.
- k_o and k_y: time in home production for old and young agents

Human Capital

The human capital of young and old agents ($i \in \{y, o\}$) in sector $j \in \{a, na\}$ and time t is

$$h_{ijt} = \exp(X_{it}\beta + U_{ij} + \lambda_{ijt}).$$

- Observable characteristics $\boldsymbol{X_{it}}$: sex, years of schooling, age, and age squared.
- Sector-specific unobserved ability U_{ij}: same for all agents within a household, but i.i.d. across households
- Sector-specific productivity shock λ_{ijt}: i.i.d. across households, sector, and time

Household Production in the Rural Area

- The agricultural household production function is

$$y_{a,t} = A_{a,t}(h_{fa,t})^{\alpha}, 0 < \alpha \leq 1,$$

where $A_{a,t}$ is the agriculture TFP, and $h_{fa,t}$ is the household's effective labor supply in agriculture: $h_{fa,t} = h_{o,t}l_{oa,t} + h_{y,t}l_{ya,t}$

- The rural non-agricultural production is

$$y_{r,t} = A_{r,t}(h_{fr,t})^{\alpha}$$

where $A_{r,t}$ is the rural non-agri TFP and $h_{fr,t} = h_{o,t}l_{or,t} + h_{y,t}l_{yr,t}$

- Household members' joint production problem is

$$\max_{l_{oa},l_{or},l_{ya},l_{yr}} \left\{p_a A_a \left(h_o l_{oa} + h_y l_{ya}\right)^{\alpha} + p_{na} A_r \left(h_o l_{or} + h_y l_{yr}\right)^{\alpha}\right\}$$

subject to

$$l_{ij} \geq 0,\ i = o, y,\ j = a, r;$$

$$l_{ia} + l_{ir} = l_i,\ i = o, y.$$

Household Production in the Rural Area

- The household production income is

$$y_f = p_a y_a + p_{na} y_r = A_f h_f^{\alpha},$$

where

$$A_f = \left[(p_a A_a)^{\frac{1}{1-\alpha}} + (p_{na} A_r)^{\frac{1}{1-\alpha}} \right]^{1-\alpha} \quad \text{and} \quad h_f = h_o l_o + h_y l_y.$$

- The household production income is allocated according to the members' effective labor input:

$$y_o = \frac{h_o l_o}{h_f} y_f \quad \text{and} \quad y_y = \frac{h_y l_y}{h_f} y_f.$$

- The effective incomes from rural area are y_o/κ_r and y_y/κ_r. The distribution cost κ_r varies across regions, provinces, and time (Brandt and Holz, 2006).

Non-agricultural Production in the Urban Area

The non-agricultural income for youth is

$$w_{na,t} h_{na,t} l_{na,t}$$

- wage per efficiency unit of labor is $w_{na,t} = p_{na} A_{na,t}$.
- $l_{na,t}$ and $h_{na,t}$ are the labor supply and human capital of the youth in the urban non-agricultural sector, respectively.
- The effective income is $w_{na,t} h_{na,t} l_{na,t} / \kappa_u$.

Incomes and Migration Costs

- Income of old agent:

$$e_o = (\frac{h_o l_o}{h_f n_o} y_f + p_a T)/\kappa_r$$

where T is the potential NRPS pension payment.

- Income of young agent:

$$e_y = (\frac{h_y l_y}{h_f n_y} y_f)/\kappa_r + [\frac{w_{na}}{n_y} h_{na} l_{na} - (m_o + m_1 \frac{l_{na}}{n_y}) w_{na} h_{na}] \mathbf{1}_{\{d=na\}}/\kappa_u.$$

where the marginal migration cost m_1 varies with:

$$m_1 = \exp((\boldsymbol{X_{it}}, \boldsymbol{Z_{it}})\zeta),$$

where $\boldsymbol{X_{it}}$ includes observed individual characteristics and $\boldsymbol{Z_{it}}$ includes an origin-based Hukou Index (Fan 2019).

▸ Hukou Index

Case of No Migration

- The parent's optimization problem is

$$\max_{l_o \in [0, n_o]} n_o \left\{ \frac{1}{1-\gamma} \left(c(e_o)\right)^{1-\gamma} - \frac{\eta}{1+\frac{1}{\phi}} \frac{\left(\xi l_o + l_y\right)^{1+\frac{1}{\phi}}}{\left(n_o + n_y\right)^{(1+\frac{1}{\phi})}} \right\}$$

- The child's optimization problem is

$$V_a = \max_{l_y \in [0, n_y]} n_y \left\{ \frac{1}{1-\gamma} \left(c(e_y)\right)^{1-\gamma} - \frac{\eta}{1+\frac{1}{\phi}} \frac{\left(\xi l_o + l_y\right)^{1+\frac{1}{\phi}}}{\left(n_o + n_y\right)^{(1+\frac{1}{\phi})}} \right\}$$

Case of Migration

- The parent's optimization problem is

$$\max_{l_o \in [0, n_o]} n_o \left\{ \frac{1}{1-\gamma} \left(c(e_o)\right)^{1-\gamma} - \frac{\eta}{1+\frac{1}{\phi}} \frac{\left(\xi l_o + l_y + l_{na}\right)^{1+\frac{1}{\phi}}}{\left(n_o + n_y\right)^{(1+\frac{1}{\phi})}} \right\}$$

- The child's optimization problem is

$$V_{na} = \max_{l_y, l_{na}; l_y + l_{na} \leq n_y} n_y \left\{ \frac{1}{1-\gamma} \left(c(e_y)\right)^{1-\gamma} - \frac{\eta}{1+\frac{1}{\phi}} \frac{\left(\xi l_o + l_y + l_{na}\right)^{1+\frac{1}{\phi}}}{\left(n_o + n_y\right)^{(1+\frac{1}{\phi})}} \right\}$$

Migration Decision

The migration decision of the young household member is given by the following condition:

$$V_{na} - V_a > U_c.$$

where U_c is an idiosyncratic migration cost shock, which follows a Normal distribution $N(0, \sigma_c^2)$.

▸ More Details of the Model

An Illustrative Special Case

Consider a special case of our general model

- Each family has one old agent and one young agent
- No rural non-agricultural sector
- Consumption equals earnings
- No diminishing return to scale in the agricultural sector
- Constant migration cost

In this case, we have

$$e_{o,j} = w_a h_o l_{o,j} + p_a T; \quad e_{y,j} = w_a h_a l_y \mathbf{1}_{\{j=a\}} + w_{na} h_{na} (l_{na} - m_0) \mathbf{1}_{\{j=na\}}.$$

where $l_{o,j}$ is the old agent's labor supply when the young agent chooses to work in sector j.

An Illustrative Special Case

Proposition 1 The household's labor allocation has the following properties:

(i) Conditional on the youth's migration status, the elderly's labor supply decrease with the pension transfer.

(ii) Conditional on their own migration status, the labor supply of young adults in agricultural and non-agricultural sectors increases with the pension transfer.

(iii) The labor supply of young adults in the non-agricultural sector increases with the migration costs.

Proposition 2 The effective migration cost has the following properties:

(i) The effective migration costs decrease with the pension transfer.

Estimation

We use Indirect Inference by matching the following moments:

- The average and variance of log urban NonAgr daily earnings and NonAgr daily earnings by education, age, and sex
- The average and variance of log rural daily Agr earnings
- Serial correlations in household daily earnings for stayers and switchers
- Average migration rate and migration rates by education, age, sex, and hukou index
- Labor supply of youth in rural and urban and labor supply of elderly in rural
- Effect of NRPS on migration rate

▸ Calibration for price

Identification

- Variances of Agr and NonAgr abilities: serial correlations of daily earnings for individuals staying in the agricultural and non-agricultural sectors
- Correlation between Agr and NonAgr abilities: serial correlation in daily earnings for those who switch sectors
- Diminishing return to labor in the rural agricultural sector, α: the effect of NRPS on migration
  - Increase elderly parents' home production time and children's labor supply
  - Diminishing returns to labor: when young workers move to the city, labor productivity in rural areas will increase, which will dampen the incentive to migrate

Table: Estimation Results

Parameter	Meaning	Estimate	Standard error
A_a	TFP level of Agri in 2003	2.300	0.0002
A_{na}	TFP level of urban NonAgri in 2003	4.083	0.0010
g_a	TFP growth rate of Agri and rural NonAgri	0.057	0.0000
g_{na}	TFP growth rate of urban NonAgri	0.110	0.0001
σ_u^a	std of Agri ability	0.741	0.0010
σ_u^{na}	std of NonAgri ability	0.472	0.0003
ρ	correlation of Agri and NonAgri ability	0.552	0.0003
σ_e^a	std of Agri productivity shock	0.570	0.0005
σ_e^{na}	std of NonAgri productivity shock	0.541	0.0007
σ_c	std of migration cost shock	0.180	0.0000
α	labor share in Agri	0.990	0.0003
η	disutility of labor supply	2.200	0.0004
ξ	relative home productivity efficiency of the elderly	5.075	0.0019

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σ_u^{na}	std of NonAgri ability	0.472	0.0003
ρ	correlation of Agri and NonAgri ability	0.552	0.0003
σ_e^a	std of Agri productivity shock	0.570	0.0005
σ_e^{na}	std of NonAgri productivity shock	0.541	0.0007
σ_c	std of migration cost shock	0.180	0.0000
α	labor share in Agri	0.990	0.0003
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Table: Estimation Results

Parameter	Meaning	Estimate	Standard error
β	coefficients in human capital equation:		
β_1	female	-0.043	0.0002
β_2	years of schooling	0.033	0.0002
β_3	age	0.073	0.0001
β_4	age squared	-0.001	0.0000
m_0	constant in migration cost	0.077	0.0001
ζ	coefficients in marginal migration costs:		
ζ_0	constant	-1.749	0.0002
ζ_1	female	1.721	0.0005
ζ_2	years of schooling	-0.107	0.0001
ζ_3	age	1.260	0.0002
ζ_4	age squared	-0.014	0.0000
ζ_5	Hukou Index	-0.407	0.0006
	overall average migration cost (% of NonAgr earnings)	70.2%	
	linear time trend in yearly average migration cost	-2.80%	

Table: Model Fit

Moments	Data	Model
A. Targeted Moments		
Average of log daily urban NonAgri earnings	3.680	3.518
Average of log daily rural Agri earnings	3.416	3.201
Linear trend of log daily urban NonAgri earnings	0.113	0.112
Linear trend of log daily rural Agri earnings	0.067	0.066
Variance of log daily urban NonAgri earnings	0.670	0.663
Variance of log daily rural Agri earnings	0.998	0.978
Serial correlation in log daily household earnings for rural stayers	0.704	0.654
Serial correlation in log daily household earnings for urban stayers	0.614	0.588
Serial correlation in log daily household earnings for rural-to-urban switchers	0.530	0.572
Regression of log daily urban NonAgri earnings on		
age	0.067	0.067
age squared	-0.001	-0.001
female	-0.093	-0.093
years of education	0.041	0.041
Regression of migration dummy on		
age	-0.057	-0.054
age squared	0.001	0.001
female	-0.158	-0.156
years of education	0.012	0.012
Hukou Index	0.053	0.053
Average migration rate	0.602	0.548
Average working days of young workers in rural areas for households with migrants	0.280	0.265
Average working days of young workers in urban areas for households with migrants	0.409	0.380
Average working days of young workers in rural areas for households without migrants	0.577	0.612
Average working days of elderly in rural areas	0.281	0.273
Effect of NRPS on migration rate for families with elderly members	0.022	0.022
B. Untargeted Moments		
Average observed APG	0.140	0.195
Linear trend in observed APG	0.051	0.045
Linear trend in migration share	0.017	0.017
Effect of NRPS on the labor supply of young workers (rural + urban areas)	0.008	0.018
Effect of NRPS on the labor supply of elderly workers in rural areas	-0.019	-0.074

Counterfactual Analysis

Close the model: Urban Workers

- $N_{u,t}$ identical urban workers with exogenous labor supply
- Wage income of urban workers is

$$w_{na} h_u l_u = p_{na} A_{na} h_u l_u,$$

where h_u and l_u are the human capital and labor supply of urban workers.

- The government levies a lump-sum tax $p_a \tau$ on the urban workers to finance the NRPS.
- The effective expenditure is

$$e_u = \left(p_{na} A_{na} h_u l_u - p_a \tau\right) / \kappa_u,$$

where κ_u is the national average urban distribution cost.

- Urban household members also have the same non-homothetic CES preferences as the rural agents.

Market Clearing Condition in Closed-Economy

- The total demand for agricultural good is

$$D_a = N_r \int p_a c_a(\boldsymbol{X}, \boldsymbol{U}, \lambda, \boldsymbol{n}, \boldsymbol{Z}) dF(\boldsymbol{X}, \boldsymbol{U}, \lambda, \boldsymbol{n}, \boldsymbol{Z}) + p_a c_a(e_u) N_u$$

- The total output of the agricultural good is

$$Y_a = N_r \int \kappa_r^{-1} p_a y_a(\boldsymbol{X}, \boldsymbol{U}, \lambda, \boldsymbol{n}, \boldsymbol{Z}) dF(\boldsymbol{X}, \boldsymbol{U}, \lambda, \boldsymbol{n}, \boldsymbol{Z}).$$

- The goods market clearing condition:

$$D_a = Y_a$$

- The government's budget constraint:

$$\left[N_r \int n_o dF(\boldsymbol{X}, \boldsymbol{U}, \lambda, \boldsymbol{n}, \boldsymbol{Z}) \right] p_a T = N_u p_a \tau.$$

Decomposition

- The changes in aggregate GDP can be decomposed into:

$$\Delta \ln(Y) = \Delta \ln(Y/H) + \Delta \ln(H/L) + \Delta \ln(L)$$

  - $\Delta \ln(Y/H)$: changes in aggregate productivity
  - $\Delta \ln(H/L)$: changes in average human capital
  - $\Delta \ln(L)$: changes in aggregate labor supply

Counterfactual: NRPS

Table: Effects of NRPS and *Hukou* Policies on GDP and Its Components

Log difference in: (relative to the baseline, log points)	GDP	Aggregate productivity	Average human capital	Aggregate labor supply
(1) Baseline: with NRPS in 2013	0.000	0.000	0.000	0.000
(2) Without NRPS	-2.241	-0.136	-0.076	-2.029
(3) NRPS scaled up fivefold	4.173	0.076	0.829	3.268
(4) *hukou* reform	2.039	0.905	1.596	-0.462
(5) 2003 hukou without NRPS	-6.556	-1.498	-3.145	-1.913

Counterfactual: NRPS

Table: Effects of NRPS and *Hukou* Policies on Labor Allocation

	Migration rate	L_{na}/L	L_o	L_y	L_{na}
(1) Baseline: with NRPS in 2013	0.637	0.377	0.089	0.975	0.848
(2) Without NRPS	0.632	0.362	0.134	0.935	0.800
(3) NRPS scaled up fivefold	0.635	0.389	0.024	1.052	0.904
(4) *hukou* reform	0.665	0.393	0.095	0.924	0.880
(5) 2003 *hukou* without NRPS	0.572	0.326	0.133	1.023	0.719

Counterfactual: Scaling up the NRPS

Table: Effects of NRPS and *Hukou* Policies on GDP and Its Components

Log difference in: (relative to the baseline, log points)	GDP	Aggregate productivity	Average human capital	Aggregate labor supply
(1) Baseline: with NRPS in 2013	0.000	0.000	0.000	0.000
(2) Without NRPS	-2.241	-0.136	-0.076	-2.029
(3) NRPS scaled up fivefold	4.173	0.076	0.829	3.268
(4) *hukou* reform	2.039	0.905	1.596	-0.462
(5) 2003 hukou without NRPS	-6.556	-1.498	-3.145	-1.913

Scaling up the NRPS

Table: Effects of the Rural Pension Policies on GDP and Welfare

	GDP	Welfare			
		Rural old	Rural young	Urban	Total (exp. equiv)
(1) Baseline: with NRPS in 2013	0.000	0.000	0.000	0.000	0.0
(2) Without NRPS	-2.241	-0.196	-0.201	0.004	-14.8
(3) NRPS scaled up fivefold	4.173	0.344	0.214	-0.012	28.5
(4) NRPS scaled up fivefold, tax rural young workers	4.656	0.343	0.080	0.004	21.3

Hukou Reform

Table: Effects of NRPS and *Hukou* Policies on GDP and Its Components

Log difference in: (relative to the baseline, log points)	GDP	Aggregate productivity	Average human capital	Aggregate labor supply
(1) Baseline: with NRPS in 2013	0.000	0.000	0.000	0.000
(2) Without NRPS	-2.241	-0.136	-0.076	-2.029
(3) NRPS scaled up fivefold	4.173	0.076	0.829	3.268
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Hukou Reform

Table: Effects of NRPS and *Hukou* Policies on Labor Allocation

	Migration rate	L_{na}/L	L_o	L_y	L_{na}
(1) Baseline: with NRPS in 2013	0.637	0.377	0.089	0.975	0.848
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(4) *hukou* reform	0.665	0.393	0.095	0.924	0.880
(5) 2003 *hukou* without NRPS	0.572	0.326	0.133	1.023	0.719

NRPS vs. *Hukou* Reform

Table: Effects of NRPS and *Hukou* Policies on the APG

	Observed APG	Underlying APG	Human Capital Gap
(1) Baseline: with NRPS in 2013	35.6	31.5	4.1
(2) Without NRPS	39.9	32.9	7.0
(3) NRPS scaled up fivefold	33.2	30.8	2.4
(4) *hukou* reform	19.2	16.5	2.7
(5) 2003 *hukou* without NRPS	62.2	52.6	9.7

Counterfactual Discussion

- NRPS improves GDP mainly through
  - Reducing within-household labor misallocation
  - increasing the labor supply of young workers in both agricultural and non-agricultural sectors
- *Hukou* reform improves GDP mainly through
  - sectoral labor reallocation, which improves aggregate productivity and average human capital

Hukou Reform and NRPS

Table: Effects of NRPS and *Hukou* Policies on GDP and Its Components

Log difference in: (relative to the baseline, log points)	GDP	Aggregate productivity	Average human capital	Aggregate labor supply
(1) Baseline: with NRPS in 2013	0.000	0.000	0.000	0.000
(2) Without NRPS	-2.241	-0.136	-0.076	-2.029
(3) NRPS scaled up fivefold	4.173	0.076	0.829	3.268
(4) *hukou* reform	2.039	0.905	1.596	-0.462
(5) 2003 hukou without NRPS	-6.556	-1.498	-3.145	-1.913

- Tombe and Zhu (2019) and Hao et al (2020): reduction of migration costs contributed to an 8.3% increase in GDP in 2005 – 2015.

Conclusion

- Use a nationally representative long-term panel dataset and a pension reform to analyze migration costs, sorting, and labor productivity in China.
- Reduced form and structural estimation results reveal substantial migration costs and a large underlying sectoral productivity difference.
- The NRPS decreases the labor supply of elderly workers while increasing the labor supply of younger household members in the non-agricultural sector, leading to higher earnings and better labor allocation within households and across sectors.

Thank you!

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Appendix

	NFP	Census,2005	
		Rural Hukou	Urban Hukou
Age	36.937	33.933	36.873
	(17.848)	(20.443)	(19.444)
Female	0.467	0.502	0.487
	(0.499)	(0.500)	(0.500)
Years of Schooling	6.779	6.509	9.728
	(3.080)	(3.559)	(4.251)
Poor Health Status	0.040	0.031	0.018
	(0.195)	(0.174)	(0.133)
Share of Workers	0.726	0.613	0.653
	(0.446)	(0.487)	(0.476)
Share of Elders	0.098	0.113	0.126
	(0.297)	(0.317)	(0.332)
Share of Workers Working in Non-agriculture	0.486	0.374	0.960
	(0.500)	(0.484)	(0.197)
Share of Workers to Migrate	0.166	0.123	0.198
	(0.373)	(0.329)	(0.399)
Rural Migrant/Urban Resident's Annual Earnings (log)	8.715	9.076	9.355
	(0.640)	(0.590)	(0.617)
Share of Migrants Working in:			
Agriculture	0.096	0.094	0.037
	(0.294)	(0.292)	(0.188)
Industry	0.256	0.463	0.266
	(0.436)	(0.499)	(0.442)
Construction	0.132	0.077	0.042
	(0.338)	(0.267)	(0.201)
Service	0.517	0.365	0.655
	(0.500)	(0.482)	(0.475)

Notes: Standard deviation in parentheses.

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Table: Sector of Employment and Annual Earnings: OLS and Individual FE

Dep. Var.: ln Annual Earnings	(1)	(2)
Migration	0.7951***	0.8085***
	(0.0120)	(0.0134)
Individual controls	Y	Y
Province× Year FE	Y	Y
Village FE	Y	N
Individual FE	N	Y
Observations	229,860	229,858
R-squared	0.3955	0.6718

▸ Return

Table: Sector of Employment and Daily Wage: Additional Results

Dep Var: ln Daily Wage	(1) IV	(2) CF	(3) CF	(4) CF
Hukou Index: below median × NonAgri	1.0063***			
	(0.3890)			
Hukou Index: above median × NonAgri	0.7640**			
	(0.3568)			
NonAgri		0.2954***	0.2945***	0.2885***
		(0.0379)	(0.0404)	(0.0404)
Residual		0.2897***	0.2697***	0.2697***
		(0.0370)	(0.0434)	(0.0437)
Residual × NonAgri		-0.4959***	-0.4601***	-0.4971***
		(0.0414)	(0.0817)	(0.0826)
Residual^2			-0.0365	-0.0056
			(0.0482)	(0.0481)
Residual^2 × NonAgri			0.0188	0.0297
			(0.0948)	(0.0951)
Residual × Z				0.2422***
				(0.0552)
Residual × NonAgri × Z				0.0784
				(0.0705)
First-stage specification		Linear + interactions with Z	Linear + interactions with Z	Linear + interactions with Z
Individual controls	Y	Y	Y	Y
Province × Year FE	Y	Y	Y	Y
Village FE	Y	Y	Y	Y
Observations	229,849	229,849	229,849	229,849
R-squared	–	0.4202	0.4202	0.4209
Kleibergen-Paap F-Stat	14.87	–	–	–

▸ Return

Table: NRPS and Sector of Employment: By Gender and the Presence of Children Aged 15 or Below

Dep. Var.:	(1) NonAgri Female	(2) NonAgri Male	(3) NonAgri All	(4) NonAgri Female	(5) NonAgri Male
Elder60 × NRPS × Child15			0.0153	0.0305**	0.0010
			(0.0115)	(0.0153)	(0.0140)
Elder60 × NRPS	0.0692***	0.0209**	0.0313***	0.0479***	0.0197*
	(0.0094)	(0.0086)	(0.0093)	(0.0125)	(0.0114)
Individual controls	Y	Y	Y	Y	Y
Province × Year FE	Y	Y	Y	Y	Y
Village FE	Y	Y	Y	Y	Y
Observations	108,041	121,807	229,849	108,041	121,807
R-squared	0.3625	0.3537	0.3630	0.3676	0.3544

▸ Return

Table: NRPS and Sector of Employment: By Education Group and Age Group

Dep. Var.:	(1) NonAgri	(2) NonAgri	(3) NonAgri	(4) NonAgri	(5) NonAgri
Sample:	Years of Education			Age	
	[0, 6]	(6, 9]	(9, 12]	[20, 39]	[40, 55]
Elder60 × NRPS	0.0416***	0.0349***	0.0358**	0.0224***	0.0652***
	(0.0111)	(0.0081)	(0.0174)	(0.0083)	(0.0103)
NRPS	-0.0029	0.0178	0.0227	0.0189	0.0068
	(0.0118)	(0.0112)	(0.0188)	(0.0136)	(0.0107)
Elder60	0.0119***	0.0302***	0.0239***	0.0134***	0.0233***
	(0.0036)	(0.0033)	(0.0079)	(0.0035)	(0.0032)
Individual controls	Y	Y	Y	Y	Y
Province × Year FE	Y	Y	Y	Y	Y
Village FE	Y	Y	Y	Y	Y
Observations	108,041	121,807	229,849	108,041	121,807
R-squared	0.3625	0.3537	0.3630	0.3676	0.3544

▸ Return

Table: NRPS and Sector of Employment: By Location and Age Group of the Elderly Member

Dep. Var.:	(1) NonAgri within County	(2) NonAgri outside County within Province	(3) NonAgri outside Province	(4) NonAgri All
Elder60 × NRPS	0.0027	0.0150***	0.0239***	
	(0.0044)	(0.0049)	(0.0068)	
NRPS	0.0132*	0.0043	-0.0064	0.0104
	(0.0069)	(0.0062)	(0.0068)	(0.0102)
Elder60	0.0024	0.0089***	0.0120***	
	(0.0015)	(0.0018)	(0.0022)	
Elder55–59×NRPS				0.0046
				(0.0080)
Elder60–69×NRPS				0.0512***
				(0.0102)
Elder≥70×NRPS				0.0359***
				(0.0088)
Elder55–59				0.0450***
				(0.0032)
Elder60–69				0.0493***
				(0.0037)
Elder≥70				0.0153***
				(0.0031)
Individual controls	Y	Y	Y	Y
Province × Year FE	Y	Y	Y	Y
Village FE	Y	Y	Y	Y
Observations	229,849	229,849	229,849	229,849
R-squared	0.1473	0.1645	0.2892	0.3626

▸ Return

Table: NRPS and Elderly Labor Supply of the Elderly

Dep. Var.: Working days	(1)	(2)	(3)	(4)	(5)
Sample:	All	Age<70	Age≥70	Good Health	Poor Health
	Poisson	Poisson	Poisson	Poisson	Poisson
NRPS	-0.0837**	-0.0932**	0.1168	-0.1283***	0.0750
	(0.0384)	(0.0383)	(0.0830)	(0.0439)	(0.0674)
Individual controls	Y	Y	Y	Y	Y
Province × Year FE	Y	Y	Y	Y	Y
Village FE	Y	Y	Y	Y	Y
Observations	46,984	29,308	17,068	23,680	23,094

▸ Return

Table: NRPS and Other Household-Level Outcomes

Dep. Var.:	(1) Savings Rate	(2) ln(1+Fixed Investment)	(3) ln(1+Loan)	(4) ΔArable Land	(5) Immediate Input per Labor Input
	OLS	OLS	OLS	OLS	OLS
Elder60×NRPS	0.0052	-0.0215	0.0297	-0.0009	0.0179
	(0.0080)	(0.0359)	(0.0452)	(0.0042)	(0.0208)
NRPS	0.0028	-0.0468	-0.0704	-0.0151*	-0.0280
	(0.0134)	(0.0648)	(0.0866)	(0.0079)	(0.0392)
Elder60	-0.0035	0.0100	-0.1294***	-0.0078***	-0.0060
	(0.0035)	(0.0153)	(0.0201)	(0.0016)	(0.0068)
Individual controls	Y	Y	Y	Y	Y
Province×Year FE	Y	Y	Y	Y	Y
Village FE	Y	Y	Y	Y	Y
Observations	107,911	110,743	110,743	103,076	101,474
R-squared	0.1201	0.0890	0.1320	0.0848	0.4475

▸ Return

Table: NRPS, Migration, and Household Wealth

Dep. Var.: NonAgri Wealth Measure:	(1) Deposits	(2) Deposits	(3) Cash	(4) Cash
Wealth: Below Median×Elder60×NRPS (β_1)	0.0586***		0.0431***	
	(0.0143)		(0.0140)	
Wealth: Above Median×Elder60×NRPS (β_2)	0.0581***		0.0640***	
	(0.0124)		(0.0110)	
Bottom Tercile×Elder60×NRPS (π_1)		0.0572***		0.0513***
		(0.0203)		(0.0167)
Middle Tercile×Elder60×NRPS (π_2)		0.0633***		0.0402***
		(0.0140)		(0.0142)
Top Tercile×Elder60×NRPS (π_3)		0.0518***		0.0690***
		(0.0147)		(0.0128)
Individual and household controls	Y	Y	Y	Y
Province×Year FE	Y	Y	Y	Y
Village FE	Y	Y	Y	Y
Observations	117,297	117,297	172,446	172,446
R-squared	0.3859	0.3863	0.3600	0.3603
F test	$\beta_1 = \beta_2$	$\pi_1 = \pi_2 = \pi_3$	$\beta_1 = \beta_2$	$\pi_1 = \pi_2 = \pi_3$
p-value	0.979	0.840	0.214	0.270

▸ Return

Consumption Allocation

The agent's consumption allocation problem is

$$\max_{c_a, c_{na}} c^r$$

subject to:

$$\varphi_a^{\frac{1}{\varepsilon}} \left(c^r\right)^{\frac{1-\varepsilon}{\varepsilon}} c_a^{\frac{\varepsilon-1}{\varepsilon}} + \varphi_{na}^{\frac{1}{\varepsilon}} \left(c^r\right)^{\frac{1-\varepsilon}{\varepsilon}} \mu c_{na}^{\frac{\varepsilon-1}{\varepsilon}} = 1,$$

and the budget constraint:

$$p_a c_a + p_{na} c_{na} = e.$$

where e is the effective expenditure.

- φ_a is the preference weight on agricultural consumption, and $\varphi_{na} = 1 - \varphi_a$.
- ε is the elasticity of substitution between agricultural and non-agricultural consumption goods.
- μ determines how the relative demand for the non-agricultural good consumption changes with income.

▸ Back

Calibration

- Construct prices for the benchmark year 2005 using the data from the GGDC productivity level database.
- Use the price index from the NBS to construct price levels for other years $\Longrightarrow$ P_a and P_{na}
- $p_a = P_a \bar{p}$ and $p_{na} = P_{na} \bar{p}$. p_a and p_{na} are in 2003 Beijing RMB.
- Use non-linear least square to estimate $\varphi_a, \varepsilon, \mu$ and $\bar{p}$ to minimize the following objective function:

$$\sum_{e \text{ of families with no elderly nor migrants}} \left[\frac{e_a}{e} - \frac{\widetilde{e_a}}{e} \right]^2$$

Table: Calibration Results

year	P_a	P_{na}
2003	0.341	0.319
2004	0.392	0.335
2005	0.384	0.346
2006	0.388	0.359
2007	0.435	0.377
2008	0.461	0.386
2009	0.466	0.392
2010	0.499	0.409
2011	0.529	0.418
2012	0.537	0.414
2013	0.541	0.409

Table: Calibration Results

	Estimated using expenditure shares:	
ε	elasticity of substitution	0.342
μ	income elasticity of non-agricultural goods	2.446
φ_a	preference weight on agricultural goods	0.698
	Taken from the literature:	
γ	1/intertemporal elasticity of substitution	1.2
ϕ	Frisch elasticity of labor supply	0.5

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Original Based Hukou Index

- Destination-based Hukou Index (Fan, 2019): reflects the prospects of long-term settlement for migrant workers at a particular destination city
- Origin-based Hukou Index:

$$Hukou\ Index_{\ell t} = \sum_{\ell' \neq \ell} \frac{OutMigrants_{\ell \ell' 0}}{OutMigrants_{\ell 0}} Hukou\ Index_{\ell' t}$$

  - Captures how easy it is for migrant workers from a particular origin prefecture to settle in cities
  - Negatively related to the migration barriers faced by migrant workers from the origin prefecture.

▸ Return

Counterfactual

Table: Effects of the Rural Pension and *Hukou* Policies on GDP and Its Components

Log difference in: (relative to the baseline, log points)	GDP	Aggregate productivity	Average human capital	Aggregate labor supply
(1) Baseline: with NRPS in 2013	0.000	0.000	0.000	0.000
(2) Without NRPS	-2.241	-0.136	-0.076	-2.029
(3) NRPS scaled up fivefold	4.173	0.076	0.829	3.268
(4) *hukou* reform	2.039	0.905	1.596	-0.462
(5) *hukou* reform without NRPS	-0.006	0.761	1.537	-2.304
(6) 2003 hukou without NRPS	-6.556	-1.498	-3.145	-1.913

Counterfactual

Table: Effects of the Rural Pension and *Hukou* Policies on Labor Allocation

	Migration rate	L_{na}/L	H_{na}/H	L_o	L_y	L_{na}
(1) Baseline: with NRPS in 2013	0.637	0.377	0.637	0.089	0.975	0.848
(2) Without NRPS	0.632	0.362	0.634	0.134	0.935	0.800
(3) NRPS scaled up fivefold	0.635	0.389	0.639	0.024	1.052	0.904
(4) *hukou* reform	0.665	0.393	0.647	0.095	0.924	0.880
(5) *hukou* reform without NRPS	0.661	0.379	0.645	0.134	0.891	0.834
(6) 2003 *hukou* without NRPS	0.572	0.326	0.612	0.133	1.023	0.719

Counterfactual

Table: Effects of the Rural Pension and *Hukou* Policies on the APG and Human Capital Gap

	Observed APG	Underlying APG	Human Capital Gap
(1) Baseline: with NRPS in 2013	35.6	31.5	4.1
(2) Without NRPS	39.9	32.9	7.0
(3) NRPS scaled up fivefold	33.2	30.8	2.4
(4) *hukou* reform	19.2	16.5	2.7
(5) *hukou* reform without NRPS	23.8	18.2	5.6
(6) 2003 *hukou* without NRPS	62.2	52.6	9.7