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

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Outline

Motivation

In developing countries:

- Labor productivity in the agricultural sector is significantly lower compared to the non-agricultural sectors, even after accounting for sectoral differences in observable worker characteristics;
- Despite the disparity in productivity between sectors, a large share of the labor force in developing countries remains in agriculture.
- This results in significant lags in aggregate productivity and income.

Research Questions

1. What are the sources of sectoral labor productivity gaps?
2. Why do developing countries fail to reallocate labor from the agricultural sector to the non-agricultural sector?
3. Are there policies that could assist these countries in improving labor allocation, thereby increasing aggregate productivity and income?

APG: Controversy

Two popular explanations for large agricultural productivity gaps (APG) in developing countries:

- Differences in unobserved worker characteristics and sorting.
- Barriers to worker mobility between agricultural and non-agricultural sectors.

The research challenge is to empirically identify these two channels:

$$APG = (\ln w_{na} - \ln w_a) + (U_{na} - U_a).$$

APG: Identification

Between 2009 and 2012, the New Rural Pension Scheme (NRPS) was rolled out across all rural counties in mainland China.

- Using an IV approach, the LATE estimate reveals an average increase of 86 log points in daily earnings for NRPS-induced, which suggests that workers who were affected by the NRPS faced high migration costs prior to the introduction of the pension policy migrants.
- Using a CF approach, We obtain an estimate of 33 log points as the ATE of migration (APG), indicating a significant underlying APG.
- This result is close to 31 log points, the OLS estimate of returns to migration ($\ln w_{na} - \ln w_a$). Thus, their similarity implies that worker sorting ($U_{na} - U_a$) plays a minor role in explaining the observed APG.

APG: Mechanism

For households with pension-eligible elderly members, after the implementation of the NRPS:

- Young workers are 4.2 percentage points more likely to be employed in urban non-agricultural sectors compared to the households without pension.
- The labor days of elders decreased, while the labor days of younger members increased.

Possible mechanism: NRPS $\xrightarrow{\text{IE}}$ labor supply of older workers $\downarrow \xrightarrow{\text{SE}}$ home production time of older workers $\uparrow \rightarrow$ home production time of younger workers $\downarrow \xrightarrow{\text{SE}}$ labor supply of younger workers $\rightarrow$ the incentive for migration to the non-agricultural sector.

Mechanism in General Equilibrium Structure

Consider a general equilibrium framework with joint household production in agriculture, shared home production, endogenous labor supply, and labor sorting across sectors.

Given that older workers typically have a comparative advantage in home production, the model predicts the introduction of the NRPS:

- Encourages migration across sectors;
- Drives reallocation of labor supply from older to younger household members, which mitigates within-family labor misallocation;

thereby enhancing overall household welfare.

Quantitative Analysis

The NRPS makes

- Migrants' labor supply $\uparrow 6\%$;
- GDP $\uparrow 2.4\%$;
- Labor supply of elderly rural workers $\downarrow 34\%$;
- Aggregate welfare $\uparrow 34\%$[1].

[1] The aggregate welfare is measured by consumption expenditure equivalents.

Counterfactual: Scaled-Up Transfer Policy

By raising the pension transfer amount fivefold, we obtain[2]

- Migrants' labor supply $\uparrow 6.6\%$;
- GDP $\uparrow 4.2\%$;
- Labor supply of elderly rural workers $\downarrow 73\%$;
- Aggregate welfare $\uparrow 28.5\%$.

[2]Comparing to the baseline case, instead of non-policy case.

Counterfactual: Liberal Household Registration Policy

By allowing all cities in China to adopt the most liberal *hukou* policy observed in the data, we suggest

- Migration rate $\uparrow 2.4$ percentage points;
- GDP $\uparrow 2.04$ percentage points;
- Observed APG $\downarrow 46\%$.

The effect of the NRPS on GDP is comparable to the effect of this migration policy reform,

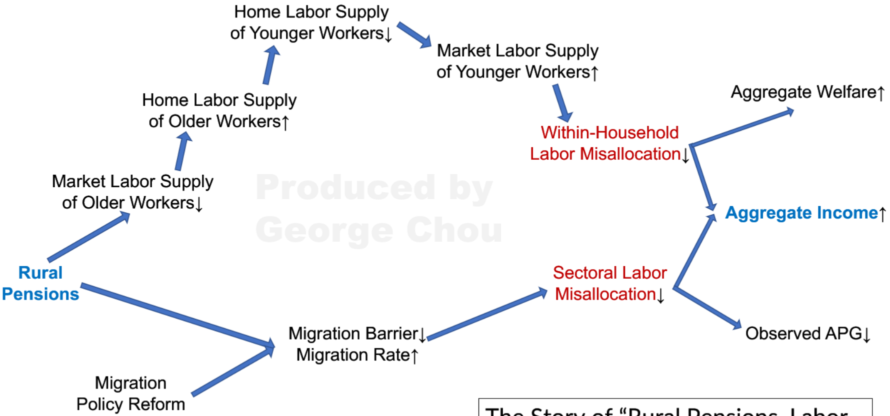
- The NRPS increases GDP primarily through reducing within-household labor misallocation and increasing aggregate labor supply.
- The migration policy reform affects GDP through sectoral labor reallocation.

Counterfactual: Policy Composition

By eliminating NRPS transfers from the benchmark model and setting each city's *hukou* policy to its 2003 level, We find that the combination of the NRPS and the actual migration policy reforms between 2003 and 2013

- Migration rate $\uparrow 6.5$ percentage points;
- GDP $\uparrow 6.6$ percentage points;
- Observed APG $\downarrow > 40\%$.

Narrative: The Story

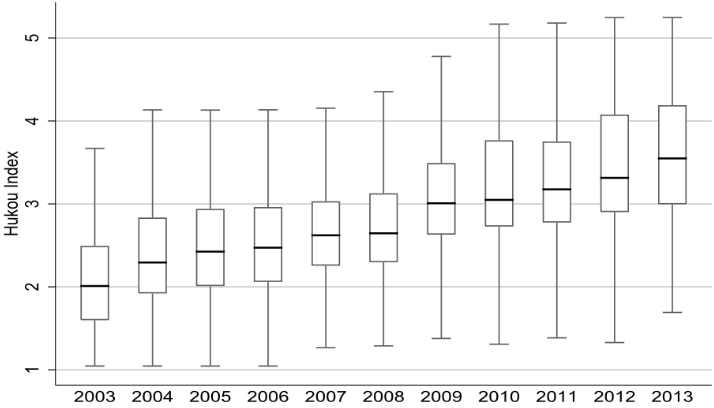


The Story of “Rural Pensions, Labor Reallocation, and Aggregate Income”

Hukou Policy

- Mainland China's household registration system is like an internal passport system where individuals' access to public services is contingent on their *hukou* status.
- Most rural-to-urban migrant workers maintain their rural *hukou*, which limits their access to urban public services. Consequently, many of them leave their children and elderly parents behind in their rural homes.
- To capture the spatial and time variation of *hukou* policies, we adapt the methodology by Fan (2019) to develop an origin-based *hukou* liberalization index.

Hukou Policy

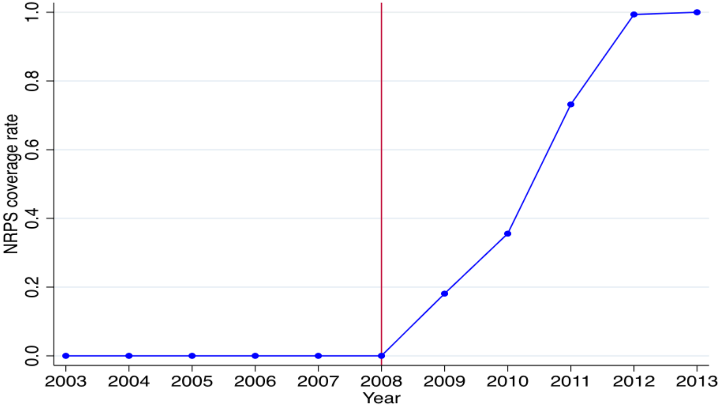


(a) Hukou Index

New Rural Pension Scheme

- In 2009, the Chinese government introduced a new pension program for rural workers: the New Rural Pension Scheme (NRPS). By the end of 2012, the NRPS had been introduced to all rural counties in mainland China.
- In our sample period, the basic benefits are effectively **direct cash transfers** from the government, as these workers had not contributed to their pensions as the NRPS was introduced only after these workers had turned 60.
- On average, these transfers account for 68% of elderly individual's income, with a standard deviation of 0.41.

New Rural Pension Scheme



(b) NRPS Coverage Rate

Data Description

- Our primary data set is the annual National Fixed Point Survey of Agriculture (NFP). It covers rural households in more than 300 villages from all 31 mainland provinces.
- In examining rural-urban migration, the NFP data set offers two advantages compared to other similar data sets:
  - It has a long panel structure covering 11 years.
  - Its geographic scope is extensive, covering agricultural and migrant workers from 350 villages across China.
- Due to the limited information on migration destinations, our analysis focuses on rural-urban migration instead of spatial movements across provinces and cities.

Migration Choice

A young rural worker migrates to the urban non-agricultural sector iff[3]

$$P := R + U_{na} - U_a > M(X, Z, T),$$

where

- $R = \ln w_{na} - \ln w_a$ is the underlying APG;
- U_s denotes the unobserved individual productivity in sectors s;
- $M(X, Z, T)$ represents the effective migration cost faced by the young rural worker, which depends on
  - X, one's individual characteristics;
  - Z, the migration policies;
  - T, the NRPS transfers to the young worker's elderly household members.

[3] See Appendix for the theoretical framework of this generalized Roy model and the details of reduced-form empirical strategy.

OLS Estimation

The OLS regression equation:

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

where

- y_{ihjt} denotes the year-t daily earnings of individual i who belongs to household h in village j;
- NonAgri_{ihjt} is a binary indicator for employment in sector na;
- X_{ihjt} is a vector of control variables, including but not limited to
  - Elder60_{hjt}, a dummy indicating whether there is a household member aged 60 or above;
  - NRPS_{jt}, the share of months in year t that the NRPS has been in effect.

OLS Estimation

- Result: $\hat{\gamma}_1 = 0.3059$.
- Problem: Notice that $\gamma_1 = \partial P$ instead of $\partial R = \partial P - \partial(U_{na} - U_a)$, so the OLS estimates are susceptible to selection bias and may fail to measure the underlying APG.
- Solution: Find exogenous shocks to migration barriers that are uncorrelated with workers' potential earnings. The gradual rollout of NRPS in counties across China constitutes such shocks.

IV Approach

The first-stage regression is

$$\mathrm{NonAgri}_{ihjt} = \beta_1 Z_{ihjt} \beta_2 + \varphi_j + \varphi_{pt} + u_{ihjt},$$

and the second stage regression is

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

where $Z_{ihjt} := \mathrm{Elder60}_{hjt} \times \mathrm{NRPS}_{jt}$.

IV Approach

The exclusion restriction for the instrument is

$$\mathrm{Cov}(Z_{ihjt}, \nu_{ihjt} | X_{ihjt}, \varphi_j, \varphi_{pt}) = 0,$$

which requires that, conditional on all observables:

- The NRPS does not directly affect income differently for individuals in households with an elderly NRPS-eligible member and individuals in households without such a member, other than its differential effect on the sector choice.
- The NRPS is uncorrelated with any other village-specific unobserved shocks whose effect on income varies according to the presence of an elderly NRPS-eligible member.

IV Approach

- Result: $\hat{\beta}_1 = 0.0418$, $\hat{\gamma}_1 = 0.8614$.
- The daily wages of NRPS-induced migrants increased ($\hat{\gamma}_1 > 0$), confirming that workers who were affected by the NRPS faced high migration costs prior to the implementation of the NRPS.
- Limitation: It is an estimate of the LATE, which captures the migration returns of the marginal workers whose sector choice was affected by the introduction of the NRPS.

Mediation Analysis

The alternative regression:

$$\ln y_{ihjt} = \gamma_1 \text{NonAgri}_{ihjt} + X_{ihjt}\gamma_2 + \gamma_3 Z_{ihjt} + \varphi_j + \varphi_{pt} + \nu_{ihjt}.$$

- Result: $t_{\gamma_3} = 1.60 < 1.64$, insignificant.
- The finding provides supportive evidence for the exclusion restriction, indicating that the NRPS affects earnings only through the channel of sector choice.

Control Function Approach

To estimate the ATE, with the assumption that U_{na} and U_a follow a joint normal distribution, we estimate the following augmented model[4]:

$$\ln y_{ihjt} = \gamma_1 \text{NonAgri}_{ihjt} + X_{ihjt}\gamma_2 + \gamma_3 \text{NonAgri}_{ihjt} \times \frac{\phi((Z_{ihjt}, W_{ihjt})\hat{\zeta})}{\Phi((Z_{ihjt}, W_{ihjt})\hat{\zeta})}$$

$$+ \gamma_4(1 - \text{NonAgri}_{ihjt}) \times \frac{\phi((Z_{ihjt}, W_{ihjt})\hat{\zeta})}{1 - \Phi((Z_{ihjt}, W_{ihjt})\hat{\zeta})} + \varphi_j + \varphi_{pt} + \nu_{ihjt},$$

where W_{ihjt} contains all the control variables (including X_{ihjt}, φ_j, and φ_{pt}), and $\hat{\zeta}$ is a vector of estimates obtained from the first-stage probit estimation of the selection equation where Z_{ihjt} serves as the excluded instrument. $\phi(\cdot)$ and $\Phi(\cdot)$ denotes the PDF and CDF of a standard normal distribution, respectively.

[4]This is called the control function approach which is founded by Card (2001).

Control Function Approach

- Result: $\hat{\gamma}_1 = 0.3261$, which represents the sectoral real wage gap for the average worker (R).
- Comparison: The result is close to the OLS estimate, which suggests that the selection bias of observed APG is almost negligible in the case of China.

Mechanism: NRPS and Labor Supply

By investigating the labor supply responses of the elderly to the introduction of the NRPS, we estimate the following equation:

$$\ln(1 + \mathrm{WorkingDays}_{ohjt}) = \alpha_1 \mathrm{NRPS}_{jt} + X_{ohjt}\alpha_2 + \varphi_j + \varphi_{pt} + \varepsilon_{ojt},$$

where $\mathrm{WorkingDays}_{ohjt}$ is the number of working days of an elderly NRPS-eligible member o in household h, village j, and year t.

- Result: $\hat{\alpha}_1 = -0.0146 < 0$. The NRPS has a significantly negative effect on older workers' labor supply.
- Robustness: To account for zero-value observations in the data, we estimate the effect of the NRPS using a Poisson quasi-maximum likelihood (Poisson MLE) model and obtain a qualitatively similar result ($\hat{\alpha}_1 = -0.0904 < 0$).

Mechanism: NRPS and Labor Supply

Turning to the labor supply responses of young workers, we estimate the triple-difference specification:

$$\ln(1 + \mathrm{WorkingDays}_{ihjt}) = \beta_1 Z_{ihjt} + X_{ihjt}\beta_2 + \varphi_j + \varphi_{pt} + \varepsilon_{ijt},$$

where $\mathrm{WorkingDays}_{ihjt}$ denotes the number of working days of a young worker i in year t who belongs to household h in village j.

- Result: $\hat{\beta}_1 = 0.0354 > 0$. The introduction of the NRPS increases the labor supply of young workers.
- Robustness: This pattern is robust when we adopt the Poisson MLE model ($\hat{\beta}_1 = 0.0145 > 0$).

Unaccomplished Questions

- What is the aggregate implication of the NRPS?
- Could the economy benefit from scaling up the pension policy?
- What are the sources of migration barriers? How would reductions in migration barriers affect the underlying APG, sorting, and aggregate productivity?

Basic Environment

- There are $N_{r,t}$ rural households. Each household has two groups of members: old agents o and young agents y.
- Assume that all household members within a group are identical and act collectively, but old agents and young agents play a **non-cooperative** Nash game[5].
- Denote $n_{o,t}$ and $n_{y,t}$ as the number of old and young agents within a family.
- Some notations: agent $i \in \{y, o\}$, sector $j \in \{a, na\}$, and time t.

[5] In contrast, a collective household model would imply a decrease in the labor supply of young agents, which contradicts our empirical results.

Human Capital

- The human capital is a function of
  - X_{it}, the observable characteristics;
  - U_j, the sector-specific unobserved ability.

  and follows a bivariate normal distribution $N(0, \Sigma_\lambda)$:

  $$h_{ijt} = \exp\left(X_{it}\beta + U_j + \lambda_{jt}\right),$$

  where the sector-specific productivity shock λ_{jt} is i.i.d. across i, j, and t.
- Since the elderly do not migrate, we denote
  - $h_{o,t}$, the human capital of o in the agricultural sector;
  - $h_{a,t}$, the human capital of y in the agricultural sector;
  - $h_{na,t}$, the human capital of y in the urban non-agricultural sector.

Household Production in Rural Areas

- A rural household can engage in both agricultural production a and rural non-agricultural production r.
- The technology function:

$$y_{j,t} = A_{j,t}(h_{fj,t})^{\alpha}, \quad 0 < \alpha \leq 1, j = a, r,$$

where

- $A_{j,t}$ is the TFP;
- $h_{fj,t} \equiv h_{o,t} l_{o,yt} + h_{a,t} l_{yj,t}$ is the household's total effective labor supply in j;
- $l_{ij,t}$ is the labor supply in j of i in the household.

Within-Household Labor Allocation

- Given the total labor supply $l_{o,t}$ and $l_{y,t}$, and output prices $p_{a,t}$ and $p_{na,t} = p_{r,t}$, the household allocates labor between a and r to maximize total household income:

$$\max_{l_{oa,t}, l_{or,t}, l_{ya,t}, l_{yr,t}} \sum_{j=a,r} p_{j,t} A_{j,t} (h_{o,t} l_{oj,t} + h_{a,t} l_{yj,t})^{\alpha}$$

s.t.

$$l_{ij.t} \geq 0 \quad \text{and} \quad l_{ia,t} + l_{ir,t} = l_{i,t}, \ i = o, y.$$

Within-Household Labor Allocation

- Define

$$A_{f,t} = \left[(p_{a,t} A_{a,t})^{\frac{1}{1-\alpha}} + (p_{na,t} A_{na,t})^{\frac{1}{1-\alpha}} \right]^{1-\alpha},$$

and

$$h_{f,t} = h_{o,t} l_{o,t} + h_{a,t} l_{y,t},$$

the household's production output in sector $j = a, r$ can be solved as

$$y_{j,t} = A_{j,t} \left(\frac{p_{j,t} A_{j,t}}{A_{f,t}} \right)^{\frac{\alpha}{1-\alpha}} h_{f,t}^{\alpha},$$

and total production income is $y_{f,t} = A_{f,t} h_{f,t}^{\alpha}$.

Within-Household Income Allocation

- Given income $y_{f,t}$, a household has to incur an exogenous iceberg distribution cost $\kappa_{r,t}$ before it can spend the income on consumption. Thus, the effective expenditure is $y_{f,t}/\kappa_{r,t}$.
- Assume that the household production income is allocated according to household members' effective labor input. Thus, the effective incomes of each agent are

$$e_{o,t} = \frac{h_{o,t} l_{o,t}}{h_{f,t} n_{o,t}} \frac{y_{f,t}}{\kappa_{r,t}} + \frac{p_{a,t} T}{\kappa_{r,t}},$$

and

$$e_{y,t} = \frac{h_{y,t} l_{y,t}}{h_{f,t} n_{y,t}} \frac{y_{f,t}}{\kappa_{r,t}},$$

where T is the pension payment, which becomes positive after the introduction of the NRPS.

Non-Agricultural Production in Urban Areas

- The technology function of non-agricultural production:

$$Y_{na,t} = A_{na,t}H_{na,t},$$

  where
  - $H_{na,t}$ is the effective units of labor in na in year t.
  - $A_{na,t}$ is the TFP of na.
- The non-agricutral wage per effeciency unit of labor is $w_{na,t} = p_{na}A_{na,t}$. Thus, the income becomes $w_{na}h_{na}l_{na,t}$.
- There is also a distribution cost $\kappa_{u,t}$ in urban areas. Therefore, the effective income is $w_{na}h_{na}l_{na,t}/\kappa_{u,t}$.

Preferences

- All members of a household have the same preferences[6]:

$$\mathcal{U}_r = \frac{c^{1-\gamma}}{1-\gamma} + G,$$

where c is an individual household member's private consumption and G is the public consumption of home production.

[6] Since labor supply and migration decisions are static problems, henceforth, we omit the time subscript t for ease of notation.

Private Consumption Allocation

- Let e be the effective expenditure of an agent; the agent's consumption allocation problem is

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

s.t.

$$p_a c_a + p_{na} c_{na} = e,$$
$$\varphi_a^{\frac{1}{\varepsilon}} c^{\frac{1-\varepsilon}{\varepsilon}} c_a^{\frac{\varepsilon-1}{\varepsilon}} + \varphi_{na}^{\frac{1}{\varepsilon}} c^{\frac{1-\varepsilon}{\varepsilon}\mu} c_{na}^{\frac{\varepsilon-1}{\varepsilon}} = 1,$$

where

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

Public Consumption

- The public consumption G depends on the time input of both old k_o and young k_y members of the household.
- Assume that

$$G = -\frac{\eta}{1+\phi^{-1}} \frac{\left[\xi(n_o - k_o) + (n_y - k_y)\right]^{1+\phi^{-1}}}{(n_o + n_y)^{1+\phi^{-1}}},$$

  where

  - η is a parameter that determines the utility of public consumption or disutility of labor supply;
  - ξ is the relative home production efficiency of the elderly.

Time Allocation

- Given the total time endowments n_o and n_y, we have

$$l_o + k_o = n_o \quad \text{and} \quad l_y + l_{na}\mathbb{I}_{\{j=na\}} + k_y = n_y,$$

where j is the migration decision of young agents.

- Therefore, an individual member allocate his time to maximize the utility below:

$$\mathcal{U}_r = \frac{c^{1-\gamma}}{1-\gamma} - \frac{\eta}{1+\phi^{-1}} \frac{\left(\xi l_o + l_y + l_{na}\mathbb{I}_{\{j=na\}}\right)^{1+\phi^{-1}}}{\left(n_o + n_y\right)^{1+\phi^{-1}}}.$$

- Notice that the household firstly solves the private consumption allocation problem, then solves this time allocation problem[7].

[7] Literally, c is determined by a non-homothetic CES utility function, see this link for details.

Labor Supply Decisions

The labor supply problem of old agents is

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

where an old agent's income is

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

Labor Supply Decisions

The labor supply decision problem of young agents is, for $j = a, na$,

$$V_j = \max_{\substack{l_y, l_{na} \in [0, n_y] \\ l_y + l_{na} \mathbb{I}_{\{j=na\}} \leq n_y}} \left\{ \frac{c(e_{y,j})^{1-\gamma}}{1-\gamma} - \frac{\eta}{1+\phi^{-1}} \frac{(\xi l_o + l_y + l_{na} \mathbb{I}_{\{j=na\}})^{1+\phi^{-1}}}{(n_o + n_y)^{1+\phi^{-1}}} \right\},$$

where an young agent's income is

$$e_{y,j} = \frac{h_y l_y}{h_f n_y} \frac{y_f}{\kappa_r} \frac{1}{\kappa_u} \left[\frac{w_{na}}{n_y} h_{na} l_{na} - \left(m_0 + m_1 \frac{l_{na}}{n_y} \right) w_{na} h_{na} \right] + \mathbb{I}_{\{j=na\}}.$$

Here, $m_0 + m_1 \frac{l_{na}}{n_y}$ is the proportional migration cost; m_0 is a constant, and $m_1 = \exp\left((X_y, Z_y)\zeta\right)$.

Migration Decision

The migration decision of young agents is given by the condition

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

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

Urban Household Decision

- There are N_u number of urban workers. Assume their human capital to be h_u. Hence, their wage income is $w_{na}h_u l_u = p_{na}A_{na}h_u l_u$.
- The government levies a lump-sum tax $p_a\tau$ on urban household member to finance the NRPS. Thus, the effective expenditure is

$$e_u = \frac{1}{\bar{\kappa}_u}(p_{na}A_{na}h_u l_u - p_a\tau).$$

- Urban household members have the same non-homothetic CES preferences as rural agents over agricultural and non-agricultural goods.
- The decision problem of urban workers:

$$V_u = \max_{l_u \in [0,1]} \left\{ \frac{c(e_u)^{1-\gamma}}{1-\gamma} - \frac{\eta}{1+\phi^{-1}} l_u^{1+\phi^{-1}} \right\}.$$

General Equilibrium Conditions

- The market-clearing conditions for
  - The agricultural goods market: $D_a = Y_a$.
  - The non-agricultural goods markets: $D_{na} = Y_r + Y_{na}$.
- The government's budget constraint:

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

which implies that the total pension transfers to the rural elderly equal the total taxes collected from the urban workers.

Solution on General Equilibrium

- In any counterfactual exercise, we can first solve τ from the government's budget constraint. Then, holding p_{na} fixed, we again use the market-clearing condition in the agricultural sector to solve for the new equilibrium price p_a.
- Given p_a, p_{na}, T, τ, and the values of all the other parameters of the model, the market-clearing condition in the agricultural sector can be used to calibrate the value of h_u.

Model Fit

The model is also consistent with the data in predicting a positive linear trend in the migration rate without assuming an exogenous reduction in the average migration cost, because of:

- A decline in migration costs due to the relaxation of *hukou* policies and the implementation of the NRPS;
- An increase in returns to migration due to higher TFP growth in the non-agricultural sector.

Decomposition

- The changes in aggregate GDP can be decomposed into changes in aggregate productivity, average human capital, and aggregate labor supply:
$$\Delta \ln Y = \Delta \ln \frac{Y}{H} + \Delta \ln \frac{H}{L} + \Delta \ln L.$$
- Aggregate productivity and average human capital can be further decomposed as follows:

$$\frac{Y}{H} = \bar{w}_a \left(1 - \frac{H_{na}}{H}\right) + \bar{w}_{na} \frac{H_{na}}{H};$$
$$\frac{H}{L} = \bar{h}_o \frac{L_o}{L} + \bar{h}_a \frac{L_y}{L} + \bar{h}_{na} \frac{L_{na}}{L} + h_u \frac{L_u}{L}.$$

Here, $\bar{w}_a$ and $\bar{w}_{na}$ denote the real value-added per unit of effective labor in the rural and urban sectors, respectively; $\bar{h}_o$, $\bar{h}_a$, $\bar{h}_{na}$, $\bar{h}_o$, h_u denote the average human capital of old rural workers, young rural workers, migrant workers, and urban residents, respectively.

Baseline Results

In the baseline case,

- $\bar{w}_a = 19.92$ and $\bar{w}_{na} = 27.23$.
  - There is a large difference between the two sectors.
- $\bar{h}_o = 1.57$, $\bar{h}_a = 2.94$, $\bar{h}_{na} = 2.95$, and $h_u = 8.16$.
  - Among workers with rural *hukou*, the human capital gap between old and young agricultural workers is large, but the gap between young agricultural workers and migrants is small.
  - Therefore, the reallocation of labor supply from old workers to young workers has an important effect on the average human capital of the whole economy.

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

	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

	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

	GDP	Welfare				
		Rural old	Rural young	Urban	Total	Total (exp. equiv)
(1) Baseline: with NRPS in 2013	0.000	0.000	0.000	0.000	0.000	0.000
(2) Without NRPS	−2.241	−0.196	−0.201	0.004	−0.394	−14.8
(3) NRPS scaled up fivefold	4.173	0.344	0.214	−0.012	0.546	28.5
(4) NRPS scaled up fivefold, tax rural young workers	4.656	0.343	0.080	0.004	0.427	21.3

Conclusion Remarks

- The NRPS in China effectively decreases the labor supply of elderly workers while increasing the labor supply of young household members in the non-agricultural sector, leading to higher earnings and better resource allocation within households and across sectors.
- The absence of adequate old-age security in rural regions acts as a barrier to labor reallocation across sectors in developing countries, and that implementing rural pension programs can facilitate enhanced labor allocation, thereby boosting aggregate income and welfare in developing countries.
- High migration costs, rather than labor sorting, predominantly explain the observed APG in China. Furthermore, there is a large gap in the average labor income between migrants and urban residents, which limits the gain from rural-urban migration in China.

Micro v.s. Macro

The same event (NRPS $\rightarrow$ social welfare), the different view.

- Huang and Zhang (2021): NRPS $\rightarrow$ multi-dimensions of individual behavior, then the welfare (by the improvement on each person).
  - Partial Equilibrium, Clear Identification, and Unique Database.
- This paper: NRPS $\rightarrow$ Rural-urban gaps, then the welfare (by the reallocation on the whole labor market).
  - General Equilibrium, Proper Structure, and Strong Narrative.

Field Top v.s. Top Five

The same topic, the different level of publication.

- Huang and Zhang (2021): Providing additional evidence to the existing theory, such as the impact of social pensions on income or health.
- This paper: Arguing the popular explanations of sectoral productivity gaps, and showing the nontrivial result on the aggregate level, instead of the structural change.

Questions are welcome.

Biases of Observed Returns to Migration

- Rewriting the generalized Roy model:

$$R + U_{na} - U_a > M(X, Z, T),$$

where $R = \ln w_{na} - \ln w_a$ is the underlying APG. Denote $d = U_{na} - U_a$ and $U = (U_a, U_{na})$.

- If workers are homogeneous with identical labor supply and human capital in both sectors, then R is identical to the observed returns to migration.
- However, with endogenous labor supply and heterogeneous worker comparative advantage $d \neq 0$, observed returns to migration are often biased measures of the underlying APG.

Biases of Observed Returns to Migration

- Let $y_a(X,U) = w_a h_a(X,U)$ and $y_{na}(X,U) = w_{na} h_{na}(X,U)$ be the daily wages in the two sectors, respectively.
- The observed log daily wage is:

$$\ln y(X,U) = \ln w_a + \mathbb{I}_{\{j=na\}} R + X\beta + U_a + \mathbb{I}_{\{j=na\}} d. \tag{A.1}$$

- Let R_{OLS} be the observed APG. We have

$$\begin{aligned} R_{\mathsf{OLS}} &= \mathbb{E}[\ln(y_{na}(X,U))|d > M(X,Z,T) - R] \\ &- \mathbb{E}[\ln(y_a(X,U))|d \leq M(X,Z,T) - R] \\ &= R + \mathbb{E}[U_{na}|d > M(X,Z,T) - R] \\ &- \mathbb{E}[U_a|d \leq M(X,Z,T) - R]. \end{aligned}$$

- Indeed, the selection bias $R_{\mathsf{OLS}} - R \neq 0$.

In the special case when U follows a bivariate normal distribution, the selection bias has the following expression[8]:

$$R_{\mathsf{OLS}} - R = \sigma_{na}\rho_{na,d}\frac{\phi\left(\frac{R-M(X,Z,T)}{\sigma_d}\right)}{\Phi\left(\frac{R-M(X,Z,T)}{\sigma_d}\right)} + \sigma_a\rho_{a,d}\frac{\phi\left(\frac{R-M(X,Z,T)}{\sigma_d}\right)}{1-\Phi\left(\frac{R-M(X,Z,T)}{\sigma_d}\right)},$$

where σ_a, σ_{na}, and σ_d are the SD of U_a, U_{na}, and d, respectively; $\rho_{a,d}$ and $\rho_{na,d}$ are the correlations of d with U_a and U_{na}, respectively; and $\phi(\cdot)$ and $\Phi(\cdot)$ denote the PDF and CDF of a standard normal distribution, respectively.

[8] See Heckman and Honore (1990).

Methods on the Selection Bias Problem

Traditional methods:

- I. Assume that the distribution of $(\exp(U_a), \exp(U_{na}))$ takes a multivariate Frechet / log-normal distribution, and uses GMM to estimate the parameters. But it is not robust to alternative distribution assumptions, so do the estimation results.
- II. Using the observed labor returns of sector switchers in panel data as estimates of the APGs. But it is not clear what the observed labor returns of sector switchers really measure.

This paper:

- Using control function approach developed by Card (2001) to estimate the generalized Roy model.

Control Function Approach

- The underlying APG can be seen as the ATE of migration:

$$R = \mathbb{E}[\ln y_{na}(X,U) - \ln y_a(X,U)].$$

- To control for selection bias, we need to use natural experiments, that is the NRPS for the case of China. Specially, we estimate equation (A.1) controlling for proxies thata capture the selection terms $\mathbb{E}[U_a|\mathbb{I}_{\{j=a\}}, X, Z]$ and $\mathbb{E}[U_{na}|\mathbb{I}_{\{j=na\}}, X, Z]$.

Control Function Approach

- The first stage: Using a probit model, we estimate the selection equation $\mathbb{I}_{\{R-M(X,Z,T)+d>0\}}$, using NRPS trasfers T as the excluded instrument.
- The second stage:

$$\ln y(X,U) = \gamma_0 + \gamma_1 \mathbb{I}_{\{j=na\}} + X\gamma_2 + \gamma_3 \mathbb{I}_{\{j=na\}} \frac{\phi((X,Z,T)\hat{\xi})}{\Phi((X,Z,T)\hat{\xi})} + \gamma_4 \mathbb{I}_{\{j=a\}} \frac{\phi((X,Z,T)\hat{\xi})}{1-\Phi((X,Z,T)\hat{\xi})} + \omega,$$

where $\hat{\zeta}$ is a vector of estimates obtained from the first-stage estimation.