

# Addressing the Demographic Decline in South Korea

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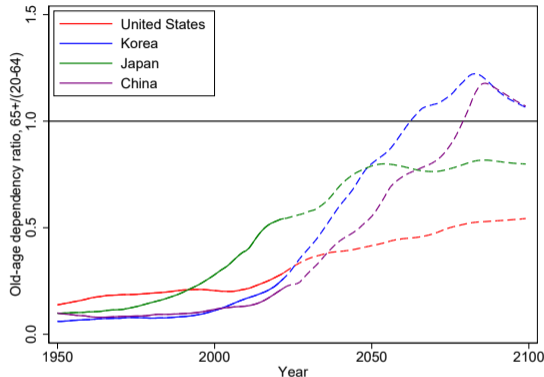
June 5, 2025

KDI JEP Conference 2025

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# Korea's aging problem

- ▶ The old-age dependency ratio is likely to pass 1 in the next 30 years.
- ▶ Korea will surpass Japan around 2050.



Notes: The old-age dependency ratio is defined as the number of people aged 65+ divided by the number of people aged 20-64. Data are derived from the UN World Population Prospects. Data past 2023 are projections, represented by dashed lines in the chart.

# Problems posed by aging populations

- ▶ Reduced potential output.
- ▶ Threatens the fiscal health of a country via the public pension.
  - Old-age share  $\uparrow$  implies less workers covering pensions of retirees.
  - Less labor taxes are collected more generally
- ▶ This paper considers reforms of the pension system as way to address the demographic decline.

## Related literature

- ▶ **Removal or privatization of public pensions.** Auerbach and Kotlikoff, 1987; Imrohoroglu et al., 1995; Conesa and Krueger, 1999; Huang et al., 1997; Huggett and Ventura, 1999.
- ▶ **Welfare effects of reforms in the U.S.** De Nardi et al., 1999; Krueger and Kubler, 2006; McGrattan and Prescott, 2017; Hosseini and Shourideh, 2019; Makarski et al., 2024.
- ▶ **Fiscal sustainability of public pensions.** Díaz-Giménez and Díaz-Saavedra, 2009; Imrohoroglu and Sudo, 2011; Ichori et al., 2011; Okamoto, 2013; Braun and Joines, 2015; Kitao, 2015; Hansen and Imrohoroglu, 2016; Hansen and Imrohoroglu, 2023.
- ▶ **Pension reform in Korea.** Kim, 2013; Baksa et al., 2024.

# Our approach

- ▶ We build an OLG incomplete markets model to assess the implications of reforms to the pension system.
  - Endogenous retirement
  - Calibration to (mostly) Korean data
  - Welfare comparison for potential pension system reforms
- ▶ We demonstrate that increasing taxes leads to lower welfare reductions than cutting benefits.
- ▶ We provide novel estimations of Koreans' retirement elasticities to income and wealth.

# Estimating retirement elasticities

- ▶ We utilize the Korean Longitudinal Study of Aging (KLoSA)
  - Covers 10,000 individuals aged 45+ every 2 years between 2006-2020.
  - Self-reported data on income, wealth, retirement status, etc. [▶ Data moments](#)
- ▶ We model retirement,  $R_{it}$ , for person  $i$  as a function of current wealth and income using a logit model:

$$\text{logit}(R_{i,t+1}) = \ln \left( \frac{\Pr(R_{i,t+1})}{1 - \Pr(R_{i,t+1})} \right) = \alpha_i + \phi_t + \beta_y y_{it} + \beta_a a_{it} + \sum_{j=1}^J \psi_j x_{jit},$$

where  $y_{it}$  is the log of after-tax income,  $a_{it}$  is the log of household wealth, and  $x_{jit}$  are a variety of additional covariates.

# Estimating retirement elasticities

|                                | Model 1             | Model 2             | Model 3             | Model 4             |
|--------------------------------|---------------------|---------------------|---------------------|---------------------|
| Log income                     | -0.23***<br>(0.002) | -3.04***<br>(0.01)  | -3.08***<br>(0.01)  | -3.12***<br>(0.01)  |
| Log wealth                     | 0.16***<br>(0.001)  | -0.09***<br>(0.003) | -0.18***<br>(0.005) | -0.19***<br>(0.005) |
| Quadratic log income           |                     | 0.44***<br>(0.002)  | 0.42***<br>(0.002)  | 0.43***<br>(0.002)  |
| Quadratic log wealth           |                     | 0.02***<br>(0.00)   | 0.02***<br>(0.00)   | 0.02***<br>(0.00)   |
| Log income $\times$ log wealth |                     |                     | 0.03***<br>(0.001)  | 0.04***<br>(0.001)  |
| Fwd. Public transfer income    |                     |                     |                     | -0.02***<br>(0.001) |

Asymptotic standard errors in parentheses. \*\*\*  $p < 0.01$ . Reported coefficients are untransformed. All regressions include age, year, and health indicator fixed effects

## Estimating retirement elasticities

- ▶ Logit models are non-linear so we need to estimate the average marginal effect numerically using the following formula where  $\epsilon > 0$  is sufficiently small:

$$\mathbf{E} \left[ \frac{\partial \Pr(R_{i,t+1} | \mathbf{e}_{it}, \mathbf{a}_{it}, \mathbf{x}_{it}, \alpha_i, \phi_t))}{\partial \mathbf{a}_{it}} \right] \approx \frac{1}{N} \sum_{i=0}^I \sum_{t=0}^{T_i} \frac{F(\mathbf{e}_{it}, \mathbf{a}_{it} + \epsilon, \mathbf{x}_{it}, \alpha_i, \phi_t) - F(\mathbf{e}_{it}, \mathbf{a}_{it}, \mathbf{x}_{it}, \alpha_i, \phi_t)}{\epsilon},$$

where

$$F(\mathbf{e}_{it}, \mathbf{a}_{it}, \mathbf{x}_{it}, \alpha_i, \phi_t) = \frac{\exp(\alpha_i + \phi_t + \beta_y \mathbf{y}_{it} + \beta_a \mathbf{a}_{it} + \sum_{j=1}^J \psi_j \mathbf{x}_{jit})}{1 + \exp(\alpha_i + \phi_t + \beta_y \mathbf{y}_{it} + \beta_a \mathbf{a}_{it} + \sum_{j=1}^J \psi_j \mathbf{x}_{jit})}.$$

## Estimating retirement elasticities

- ▶ Koreans' retirement decisions are minimally sensitive to changes in wealth and income.
- ▶ Our estimated elasticities are robust to different specifications.

|                         | Model 1          | Model 2          | Model 3          | Model 4          |
|-------------------------|------------------|------------------|------------------|------------------|
| Log income AME [95% CI] | -.02 [-.02,-.02] | -.02 [-.02,-.02] | -.02 [-.02,-.02] | -.02 [-.02,-.02] |
| Log wealth AME [95% CI] | .01 [.01,.01]    | .01 [.01,.01]    | .01 [.01,.01]    | .01 [.01,.01]    |

▶▶ Other estimators

## Korea's retirement system

- ▶ Our analysis focuses on the national pension scheme.
  - Those over 65 are eligible as of 2023.
  - Those over 55 can receive reduced benefits.
- ▶ Under the NPS the annual benefit formula is given by:

$$b = \alpha \frac{Y + y}{2} \times \frac{0.05n}{2} \quad (1)$$

where  $\alpha$  governs the replacement rate and is set to 0.40.  $y$  is the average annual income a participant,  $Y$  is the average income of all participants over the past three years, and  $n$  is the number of contributed years.

## Korea's retirement system

- ▶ Abstracting from growth, the retirement benefit for any individual 65 years of age or older with more than 10 years of contributions can be expressed as

$$\frac{b(e_T)}{Y} = 0.005e_T, \quad (2)$$

where  $T$  is the period of retirement and

$$e_{t+1}^i = e_t^i + 1 + \max \left\{ 0.1, \min \left\{ 1.65, \frac{y_t^i}{Y} \right\} \right\} \quad (3)$$

where  $y_t^i$  is annual earnings of individual  $i$  in period  $t$ .

- ▶ The total contribution rate is 9 percent, with half being paid by the employer for workplace-based insured individuals.

# Model

- ▶ Households have a life cycle as in [Yaari, 1965](#) and [Blanchard, 1985](#)
- ▶ Households with assets,  $a$ , and labor productivity,  $\epsilon$ , face idiosyncratic labor productivity risk.
  - Households can accumulate non-state-contingent assets.
- ▶ There are 3 kinds of households: young worker, worker, and retiree, denoted by  $j \in Y, W, R$ , repetitively.

# Model

- ▶ Old workers make a retirement decision each period based on the draw of a preference shock from a Type-I Extreme Value distribution.
  - The preference shocks allow for the retirement decision to depend on other non-modeled factors such as health, family, and other personal matters.
  - Retired households receive a retirement benefit based on lifetime earnings,  $e$ , and their wealth.
  - Each retired household has a probability of dying each period,  $\delta_R$ .
  - Deceased households transfer assets and productivity to a newborn worker household.
- ▶ Worker households supply  $\ell z$  efficiency units of labor, where  $\ell$  and  $z$  denote hours supplied and labor productivity, respectively.
  - We assume that  $z$  follows a Markov process with transition matrix  $\Gamma(z, z')$ .
  - Let  $y = w\ell z$  denote a household's pre-tax earnings.
  - The government taxes earnings at a flat rate  $\tau_t$ , funding retirement benefits,  $b_t(e)$ .

## Retirees' problem

- ▶ A retiree household with wealth  $a$  and lifetime earnings  $e$  in period  $t$  solves

$$V_t^R(a, e) = \max_{c, a'} u(c) + \beta [(1 - \delta_R)V_{t+1}^R(a', e) + \delta_R\Omega(a')] \quad (4)$$

s.t.  $c + a' \leq (1 + r_t)a + b_t(e),$   
 $a' \geq 0.$

- ▶  $r_t$  is the return on assets.
- ▶  $b_t(e)$  is the retirement benefit, which depends on lifetime earnings.
- ▶  $\Omega$  reflects 'warm glow' utility from bequests.

## Worker households' problem

- ▶ The problem of a worker household with wealth,  $a$ , productivity,  $z$ , and previous earnings,  $e$ , in period  $t$  can be stated as:

$$V_t^W(a, z, e) = \max_{c, \ell, a'} u(c, \ell) + \mathbf{E}_{\varepsilon_t} \left[ \max_{j=W, R} \left\{ \beta \mathbf{E}_{z'|z} V_{t+1}^j(a', z', e') - \tau_{Wj} + \nu \varepsilon_t^j \right\} \right]$$

s.t.  $c + a' \leq (1 - \tau_t) w_t z \ell + (1 + r_t) a,$   
 $e' = g(e, w_t z \ell),$   
 $a' \geq 0.$

- ▶  $g$  updates lifetime earnings based on previous lifetime and current earnings.
- ▶  $\tau_{ij}$  is the cost of switching from life stage  $i$  to  $j$ .
- ▶  $\varepsilon \equiv \{\varepsilon_W, \varepsilon_R\}$  is a pair of idiosyncratic preference shocks, which are realized at the end of period  $t$ . They are i.i.d. and Type-1 extreme value distributed with zero mean.

## Worker households' problem

- ▶ Our preference shock assumption allows us to simplify the worker problem:

$$V_t^W(a, z, e) = \max_{c, \ell, a'} u(c, \ell) + \nu \log \left\{ \sum_{j=W, R} \exp \left( \beta \mathbf{E}_{z'|z} V_{t+1}^j(a', z', e') - \tau_{ij} \right)^{\frac{1}{\nu}} \right\}$$

s.t.  $c + a' \leq (1 - \tau_t) w_t z \ell + (1 + r_t) a,$   
 $e' = g(e, w_t z \ell),$   
 $a' \geq 0.$

## Households' problem

- ▶ It is then possible to express the retirement probability as:

$$\rho_t(a', e'|z) = \frac{\exp(\beta \mathbf{E}_{z'|z} V_{t+1}^R(a', z', e') - \tau_{WR})^{\frac{1}{\nu}}}{\sum_{k=W,R} \exp(\beta \mathbf{E}_{z'|z} V_{t+1}^k(a', z', e') - \tau_{Wk})^{\frac{1}{\nu}}}. \quad (5)$$

- ▶  $\nu$  governs the elasticity to which retirement depend on economic variables.
- ▶ As  $\nu \rightarrow \infty$ , workers retire for purely random reasons.

## Young households' problem

- ▶ A young worker household with wealth,  $a$ , productivity,  $z$ , and previous earnings,  $e$ , in period  $t$  can be stated as:

$$V_t^Y(a, z, e) = \max_{c, \ell, a'} u(c, \ell) + \beta \mathbf{E}_{z'|z} [\delta_W V_{t+1}^W(a', z', e') + (1 - \delta_W) V_{t+1}^Y(a', z', e')]$$

s.t.  $c + a' \leq (1 - \tau_t) \Gamma_Y w_t \ell + (1 + r_t) a,$   
 $e' = g(e, w_t \ell),$   
 $a' \geq 0.$

- ▶  $\delta_W$  is the fixed probability that a young worker transits to a worker household stage.

# Representative Firm's Problem

- ▶ The firm uses labor and capital according to constant returns to scale of technology  $F(N, K)$
- ▶ Firm optimality conditions imply that factor prices are given by  $w_t = F_{Nt}$  and  $r_t = F_{Kt} - \delta$ 
  - $\delta$  is the depreciation rate of capital
- ▶  $\mu_t^j(a, \varepsilon, e)$  denotes the measure of households with life stage  $j \in \{Y, W, R\}$ , wealth  $a$ , productivity  $z$ , and previous earnings,  $e$ .

# Competitive equilibrium

- A competitive equilibrium is household and firm allocations and prices, such that
- given prices and taxes, household and firm allocations are optimal,
  - government budget constraints are satisfied, and
  - markets clear:

$$F(K_t, N_t) = \sum_{j \in \{Y, W, R\}} \int \left( c_t^j(a, z, e) + a'_{jt}(a, z, e) - a(1 - \delta) \right) d\mu_t, \quad (6)$$

$$N_t = \sum_{j \in \{Y, W\}} \int z \Gamma_j \ell_t(a, z, e) d\mu_t, \quad (7)$$

$$K_t = \sum_{j \in \{Y, W, R\}} \int a'_{jt}(a, z, e) d\mu_t. \quad (8)$$

## Functional forms

- ▶ Worker preferences are separable in consumption and leisure and their period utility takes the following form:

$$u(c, \ell) = \frac{c^{1-\sigma} - 1}{1 - \sigma} - \theta_h \frac{h^{1+\psi}}{1 + \psi}.$$

- ▶ Retirees have the same CRRA utility function over consumption, but in place of a labor disutility term, they derive warm-glow utility from leaving a bequest,

$$\Omega(a') = \theta_1 \frac{(a' + \theta_2)^{1-\gamma_b}}{1 - \gamma_b}.$$

- ▶ We assume that production takes the form,

$$F(K, N) = ZK_t^\alpha N_t^{1-\alpha},$$

## Calibration (preferences)

| Parameters                                 | Values | Targets / Source  |
|--|--------|---|
| Discount factor, $\beta$                   | 0.92   | Wealth-to-GDP: 3.8 (OECD)   |
| Risk aversion, $\sigma$                    | 2      | Standard value  |
| Disutility from labor, $\theta_h$          | 20.7   | Average hours per worker: 43.8 (OECD)                             |
| Frisch elasticity, $1/\psi$                | 0.5    | Standard value  |
| Bequest function,                          |        |   |
| Strength of bequest preference, $\theta_1$ | 9.5    | Average wealth of retired households: 5 (KLoSA)                   |
| Non-homotheticity parameter, $\theta_2$    | 2.0    | Fraction of young households with non-positive wealth: 30 percent |
| Curvature on bequests, $\gamma_b$          | 0.75   | Wealth Gini: 0.61 (Statistics Korea)                              |

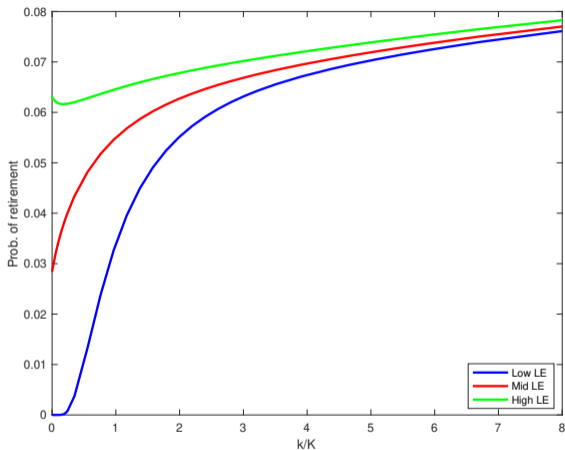
# Calibration (demographics and pension)

| Parameters                         | Values | Targets / Source   |
|------------------------------------|--------|--|
| Aging and retirement,              |        |  |
| Probability of old worker, $\pi_a$ | 0.05   | Expected young worker years: 20  |
| Retirement disutility, $\tau_{WR}$ | 60     | Expected retirement age: 65  |
| Variance of shocks, $\nu$          | 20     | Retirement semi-elasticity of wealth: 0.01   |
| Death probability, $\pi_d$         | 0.05   | Expected retirement years (conditional on 65):<br>20.7 (2024 Statistics on the Aged) |
| Old worker wage premium            | 1.5    | Ratio of old to young worker income: 1.5   |
| Fiscal parameters                  |        |  |
| Social security, $\tau_{SS}$       | 0.09   | National Pension scheme  |
| Replacement rate, $b$              | 0.005  | Replacement rate for average worker with<br>40 years of contributions: 40 percent    |

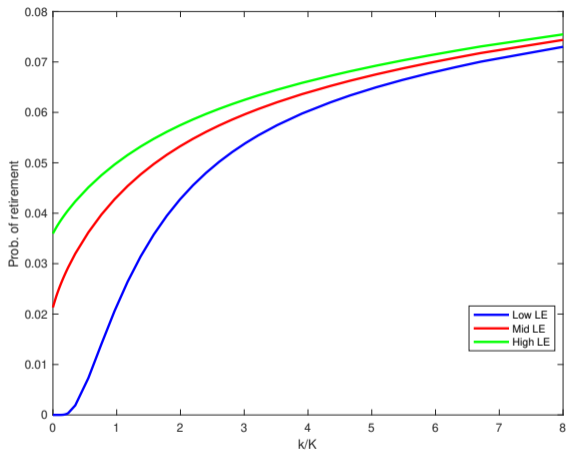
## Calibration (technology and shocks)

| Parameters                          | Values | Targets / Source    |
|-------------------------------------|--------|---------------------|
| Capital share, $\alpha$             | 0.36   | Standard value      |
| Capital depreciation rate, $\delta$ | 0.05   | Standard value      |
| Wage process,                       |        |                     |
| Persistence, $\rho$                 | 0.800  | Chang and Kim, 2008 |
| standard deviation, $\sigma$        | 0.354  | Chang and Kim, 2008 |

# Optimal retirement decision



(a) Lowest wage



(b) Highest wage

Notes: These figures plot the retirement probability of a middle-aged worker household as a function of wage, lifetime earnings (LE), and wealth (in multiples of mean wealth). The wealth values plotted cover 99.99% of households.

# Experiments

- ▶ We change  $\pi_d$  from 5.0% to 2.5% to induce aging and double the old-age dependency ratio in the long-run (from 0.5 to 1).
- ▶ We test policy responses where the government increases taxes or reduces benefits.

## Aggregate responses

|            | $\tau$ | $b$   | GDP  | K   | C    | $r$  | $w$  | Dep. Ratio | $\frac{\text{Deficit}}{\text{GDP}}$ |
|------------|--------|-------|------|-----|------|------|------|------------|-------------------------------------|
| Initial SS | 9.0%   | 0.50% | 1.00 | 4.0 | 0.84 | 3.9% | 1.77 | 0.50       | 4.5%                                |
| No Reform  | 9.0%   | 0.50% | 0.80 | 3.0 | 0.76 | 4.4% | 1.72 | 0.86       | 11.0%                               |
| Taxes      | 31.3%  | 0.50% | 0.78 | 2.6 | 0.64 | 5.5% | 1.61 | 0.88       | 0%                                  |
| Benefits   | 9.0%   | 0.17% | 0.93 | 4.1 | 0.72 | 3.2% | 1.85 | 0.76       | 0%                                  |

- ▶ Closing the deficit requires large tax increase or benefit reduction.
- ▶ Large GE effects: Higher taxes lead to lower capital and wages. Benefit reform leads to the opposite.
- ▶ Dependency ratio does not double because of delayed retirement.

# Compositional change

|                 | Young | Middle | Retired |
|-----------------|-------|--------|---------|
| Raise Taxes     | +0.3  | -0.9   | +0.6    |
| Reduce Benefits | -1.6  | +4.6   | -3.0    |

Units: Percentage points.

Notes: This table reports endogenous changes in population shares relative to the 'No Reform' case with demographic change (i.e.,  $\pi_d = 2.5\%$ ).

- ▶ Raising taxes induces earlier retirement relative to no reform
- ▶ Reducing benefits has the opposite effect

# Welfare

|                | Young | Middle | Retired | All   |
|----------------|-------|--------|---------|-------|
| Raise Taxes    | -3.0  | -1.3   | 1.6     | -0.2  |
| Reduce Benefit | -0.4  | -4.2   | -31.9   | -16.0 |

Units: Consumption equivalents, percent.

Notes: This table reports the welfare difference relative to the 'No Reform' case with demographic change (i.e.,  $\pi_d = 2.5\%$ ).

- ▶ Conceptual question: If you ask a young worker how much lifetime consumption would s/he be willing to give up to be dropped in the 'no reform' steady state and not the reform steady state.
- ▶ Large distributional effects:
  - Raising taxes disproportionately benefit retirees at the expense of young workers.
  - Benefit reduction clearly hurts retirees.
- ▶ Taking into account the average, raising taxes clearly the better of the two.

## Concluding remarks

- ▶ We quantitatively investigated the impacts of potential pension reforms in Korea as responses to an aging population.
- ▶ Raising taxes to fund increasing pension liabilities leads to a smaller overall welfare reduction compared to cutting benefits.
- ▶ The model matches the limited importance of wealth and income in determining when Korean workers retire.
- ▶ Future work should consider optimal policy, additional policy levers such as retirement age, and the transition paths to new policy steady states.

## Appendix Slides

# Retirement elasticities

|                           | Logit                  | Probit                 | Tobit                  |
|---------------------------|------------------------|------------------------|------------------------|
| Fwd. retirement indicator |                        |                        |                        |
| Log income                | -0.2295***<br>(0.0019) | -0.1328***<br>(0.0009) | -0.0165***<br>(0.0001) |
| Log wealth                | 0.1561***<br>(0.0009)  | 0.0824***<br>(0.0004)  | 0.0102***<br>(0.0001)  |
| Observations              | 15492663               | 15492663               | 15492663               |
| Age FE                    | Yes                    | Yes                    | Yes                    |
| Survey Year FE            | Yes                    | Yes                    | Yes                    |
| Health FE                 | Yes                    | Yes                    | Yes                    |
| Log income mean (SD)      | 3.04 (.76)             | 3.04 (.76)             | 3.04 (.76)             |
| Log wealth mean (SD)      | 4.86 (1.6)             | 4.86 (1.6)             | 4.86 (1.6)             |
| Log income AME [95% CI]   | -.02 [-.02,-.02]       | -.02 [-.02,-.02]       | -.02 [-.02,-.02]       |
| Log wealth AME [95% CI]   | .01 [.01,.01]          | .01 [.01,.01]          | .01 [.01,.01]          |

Asymptotic standard errors in parentheses. \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Reported coefficients are untransformed. The reported AME statistics represent the average change in retirement probability associated with a one unit increase in log income or log wealth.

## KLoSA data moments

|                          | Mean  | SD    | Min  | Max    | 25th pct. | 75th pct. |
|--------------------------|-------|-------|------|--------|-----------|-----------|
| Workers                  |       |       |      |        |           |           |
| Income                   | 26.6  | 18.8  | 1.3  | 100.0  | 13.1      | 35.0      |
| Wealth, HH               | 217.6 | 275.9 | 0.0  | 1700.0 | 32.6      | 286.1     |
| Public transfer income   | 1.1   | 3.2   | 0.0  | 40.0   | 0.0       | 0.0       |
| National pension         | 0.6   | 1.9   | 0.0  | 18.0   | 0.0       | 0.0       |
| Basic retirement benefit | 0.1   | 0.4   | 0.0  | 3.4    | 0.0       | 0.0       |
| Respondent age           | 58.2  | 7.4   | 45.0 | 96.0   | 53.0      | 62.0      |
| Self-employed income     | 0.0   | 0.3   | 0.0  | 9.2    | 0.0       | 0.0       |
| Hours per week           | 44.4  | 13.0  | 10.0 | 84.0   | 40.0      | 50.0      |
| Wage                     | 23.8  | 19.9  | 0.0  | 92.0   | 10.9      | 32.1      |

Data are winzORIZED at the 1 percent level. The variables with the HH marker are values for households. These moments are calculated after excluding self-employed, never-employed, and weakly attached to the labor market individuals.

# KLoSA data moments

|                                 | Mean  | SD    | Min  | Max    | 25th pct. | 75th pct. |
|---------------------------------|-------|-------|------|--------|-----------|-----------|
| Retirees                        |       |       |      |        |           |           |
| Income                          | 2.9   | 8.7   | 0.0  | 100.0  | 0.0       | 0.0       |
| Wealth, HH                      | 251.9 | 321.4 | 0.0  | 1700.0 | 40.8      | 330.3     |
| Public transfer income          | 4.2   | 7.9   | 0.0  | 40.0   | 0.0       | 4.2       |
| National pension                | 1.2   | 2.6   | 0.0  | 18.0   | 0.0       | 1.5       |
| Basic retirement benefit        | 0.4   | 0.8   | 0.0  | 3.4    | 0.0       | 0.0       |
| Respondent age                  | 68.4  | 9.3   | 45.0 | 102.0  | 62.0      | 75.0      |
| Retirement age                  | 60.4  | 10.2  | 28.0 | 83.0   | 55.0      | 67.0      |
| Age first getting natl pension  | 62.4  | 5.4   | 47.0 | 78.0   | 60.0      | 64.0      |
| Age first getting basic pension | 68.4  | 5.3   | 58.0 | 85.0   | 65.0      | 71.0      |
| Self-employed income            | 0.6   | 4.5   | 0.0  | 115.0  | 0.0       | 0.0       |
| Hours per week                  | 4.7   | 13.8  | 0.0  | 84.0   | 0.0       | 0.0       |
| Wage                            | 2.1   | 7.4   | 0.0  | 92.0   | 0.0       | 0.0       |

Data are winzorized at the 1 percent level. The variables with the HH marker are values for households. These moments are calculated after excluding self-employed, never-employed, and weakly attached to the labor market individuals.