General Equilibrium Fiscal Model

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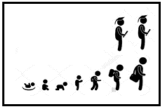
Ministerio de Hacienda y Crédito Público

This version, May 2016

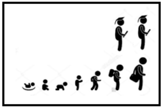
Outline

14 Million People Born in the 50's and 60's

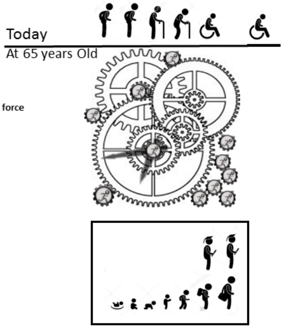


14 Million People Born in the 50's and 60's

- 51% labor force
- 45% GDP



14 Million People Born in the 50's and 60's: resources?



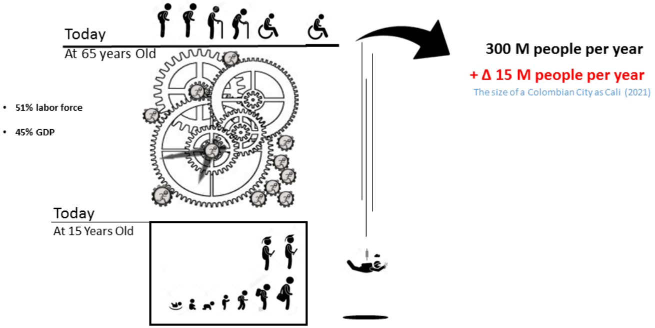
- 51% labor force
- 45% GDP

300 M people per year

+ Δ 15 M people per year

The size of a Colombian City as Cali (2021)

14 Million People Born in the 50's and 60's



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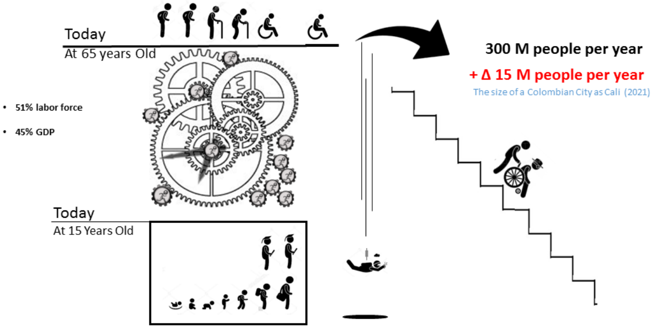
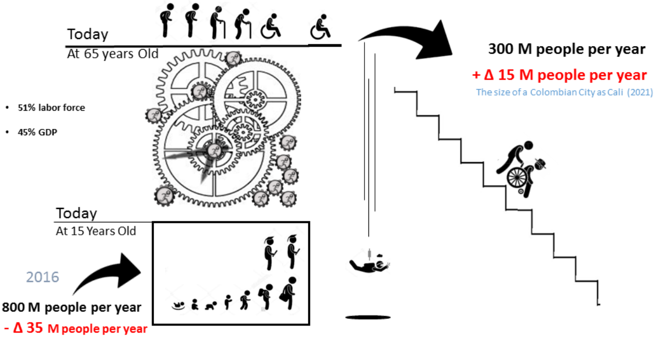
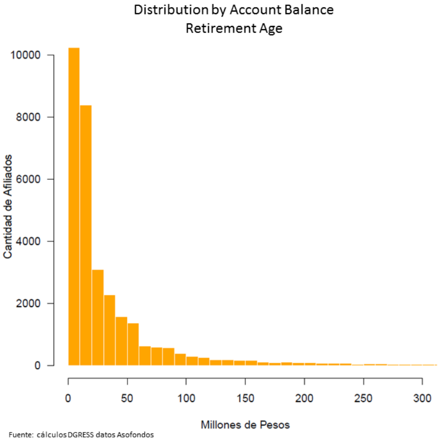


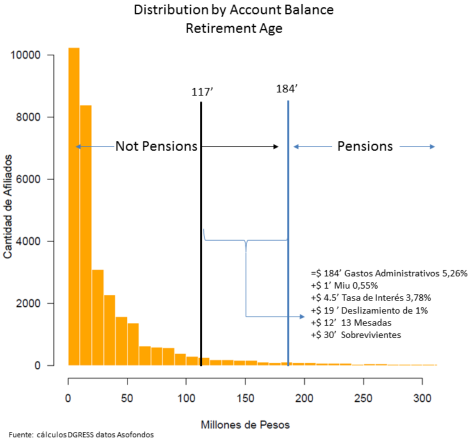
2041: the year of complete reshape in population flows



Inequality along life I

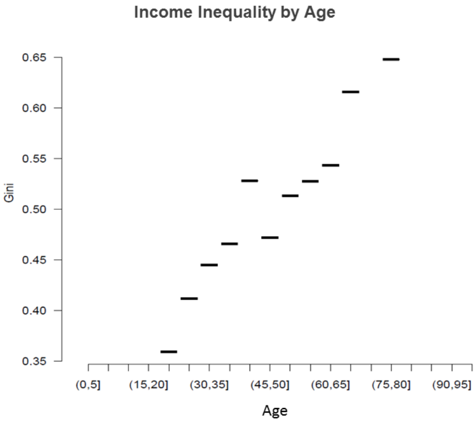


Inequality along life II



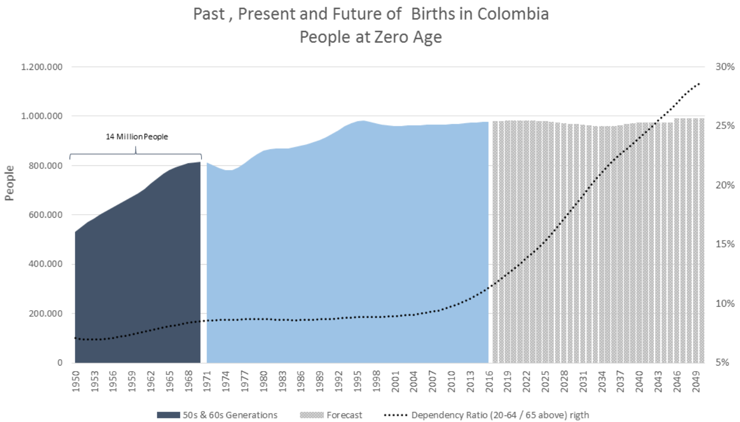
Fuente: cálculos DGRESS datos Asofondos

Inequality along life III



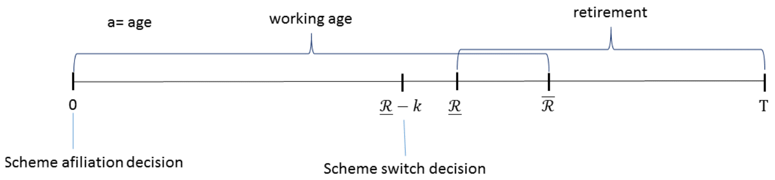
Fuente: GEIH – Cálculos DGRESS-MHCP

Evolution of Dependency Ratio



Source: MHCP using data from UN and ECLAC

Time allocation



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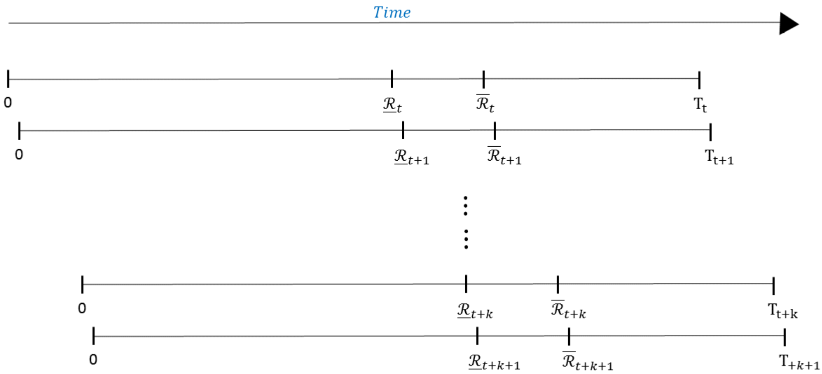

Previous Work

- OCDE: Partial and GE models.
- DNPENSION. Have a microdata approach that can be complementary.
- World Bank. PROST Model.
- IMF: GFM and GIMF. Candidate.(Non-Ricardian Features ; Short Run Effectiveness and Long Run Sustainability -> Fiscal Deficits, Current Account Deficits, etc.)

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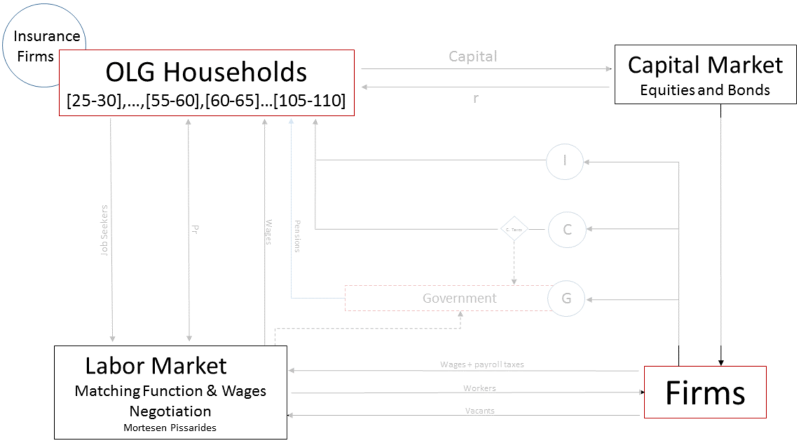

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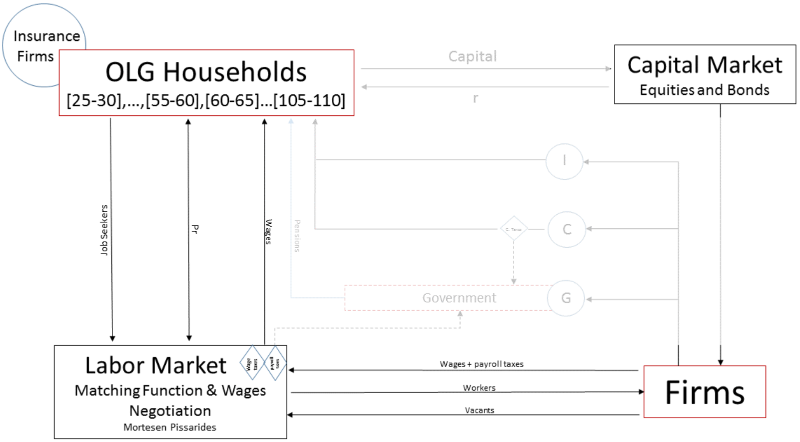

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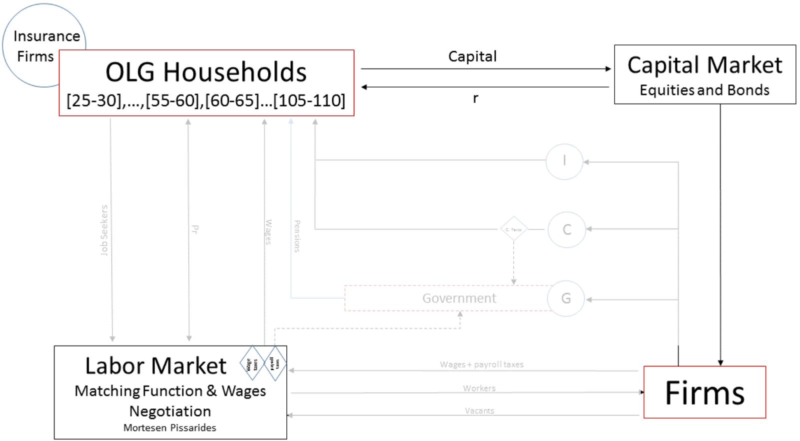

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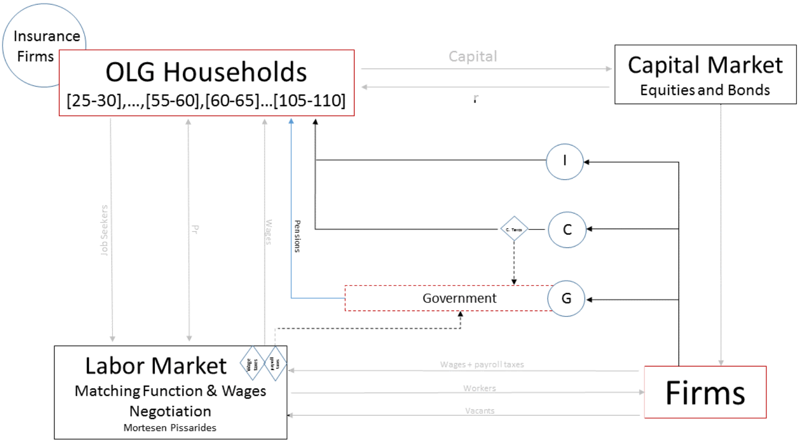

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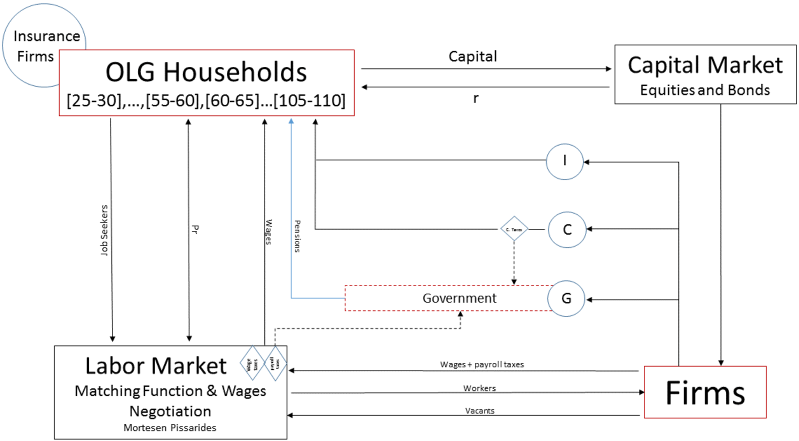

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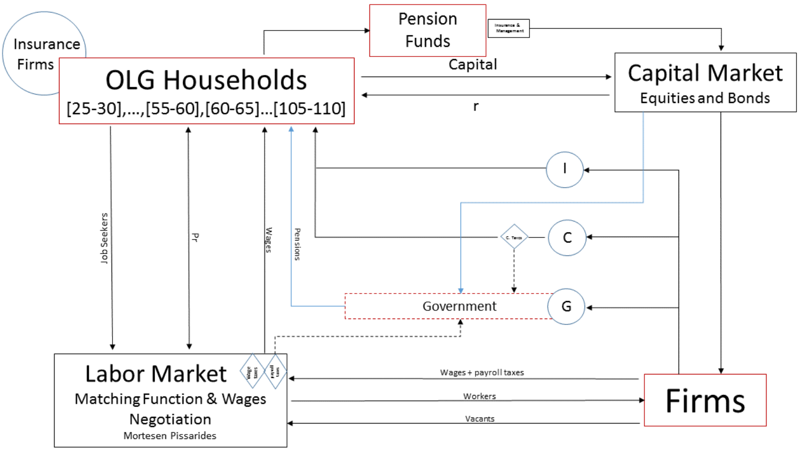

Outline

Population

- New Generations Z_0 born each period (time is indexed by t)

$$\overbrace{Z_{0,t}}^{\text{New generations}} = (1+x_t)\overbrace{Z_{0,t-1}}^{\text{Past generations}} \quad ,\forall t > 0$$

- And dynamic probabilities $\beta_{a,t+a}$ determine the survival of each cohort

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Population

- Working age population P is defined as

$$P_{a,t+a} = z_{a,t+a} Z_{a,t+a},\; z_{a,t+a} = 1 \; if \; 0 \leq a \leq 7 \; z_{a,t+a} = 0 \; instead$$

- Working age population includes employees n, unemployees u and pensioners p

$$P_{a,t} = \left[n_{a,t} + u_{a,t} + p_{a,t} \right] P_{a,t}$$

- People above working age population can be pensioners with $pr < 1$:

$$Z_{a,t} = \left[p_{a,t} + \check{p}_{a,t} \right] Z_{a,t},\; for \; a \geq \overline{R}$$

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Population

- Retirees in the Public Scheme are all eligible candidates $\hat{\varphi}$:

$$\overbrace{p^{Pu}_{a,t}}^{\text{pensioners stock}} = \overbrace{v_{a-(a-\overline{R}),t-(a-\overline{R})}}^{\text{affiliates}} \overbrace{\sum_{i=0}^{a-\overline{R}}}^{\text{previous and current candidates}} \hat{\varphi}^{Pu}_{a-i,t-i}, \text{ for } a \geq \underline{R}$$

- Once maximum retirement age $\overline{R}$ is achieved:

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Candidates for pension: Public Scheme

- Eligible candidates are a result of non-meditated decisions (early members afiliationsα), switchingς:

$$\overbrace{v_{a,t}}^{\text{affiliates at } t} = [\overbrace{\alpha_{t-a}}^{\text{affiliates at } t-a} \left(1-\overbrace{\varsigma_{t-(a-(\underline{R}-\kappa))}}^{\text{members outflow}}\right) + (1-\alpha_{t-a})\overbrace{\varsigma^{pr}_{t-(a-(\underline{R}-\kappa))}}^{\text{members inflow}}], \; \textit{for } a \geq \overline{R}$$

- And labor histories

$$\varphi_{a,t} = \overbrace{\mathrm{tr}(\Lambda_{a-1,t+a-1}\Xi'_{a-1,t-1})}^{\textit{People with at least } 1.300 \textit{ work weeks}} \quad \textit{if } a = \underline{R}$$

where

$$\Xi_{a,t,\{i,j\}} = \begin{cases} 1 & \textit{if } \vartheta_{a,i,j} \geq \gamma \\ 0 & \textit{otherwise} \end{cases} \quad \textit{for } a = \underline{R}$$

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$$t=0 \rightarrow \Lambda_{1,t} = \begin{bmatrix} EE & UE \\ EU & UU \end{bmatrix} = \begin{bmatrix} EE & UE \\ EU & UU \end{bmatrix} \begin{bmatrix} E & 0 \\ 0 & U \end{bmatrix}$$

$$t=1 \rightarrow \Lambda_{2,t+1} = \begin{bmatrix} EEE & UEE & EUE & UUE \\ EEU & UEU & EUU & UUU \end{bmatrix} = \begin{bmatrix} EE & UE \\ EU & UU \end{bmatrix} \begin{bmatrix} EE & UE & 0 & 0 \\ 0 & 0 & EU & UU \end{bmatrix}$$

$$\vartheta_{a+1} = [1+\vartheta_a : \vartheta_a], \; with \; \vartheta_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

Candidates for Pension: Private Scheme

- Individual accounts balance at age $\underline{R}$ are

$$\iota_{\underline{R},t} = [\tau w]_t^{Pr} \begin{bmatrix} R_{\underline{R},t-\underline{R}} \\ \vdots \\ R_{1,t-1} \\ 1 \end{bmatrix},$$

where $R_{a,t+a}$ is the cummulative compounded interest rate.

- Minimum balance requirement

$$\underline{k}_{a,t} = \sum_{i=0}^{T-a} \frac{(1+\varepsilon_{t+i})\, w_{0,t+i} (1+\triangle_{t+i})^i}{\prod_{j=0}^{i} R_{t+j}} \frac{\beta_{a+i,t-i}}{\beta_{a,t}} (1+\mu_{t+i}), \underline{R} \leq a \leq \overline{R}$$

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- Elegibility by capital balance in the private scheme is therefore:

$$\varphi^{k}_{a,t} = \Pr(\iota_{a-1,t+a-1} \geq \underline{k}_{a,t})$$

- Labor histories and contributions are stored in $[\tau w]^{Pr}_{t}$

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Outline

Job seekers and trade

- At age a job seekers Ω are:

$$\Omega_{a,t} = \overbrace{[1-(1-\chi_t)\, n_{a-1,t-1}]}^{\textit{fired+unemployed}} \overbrace{(1-p_{a,t})}^{\textit{not retirees}} P_{a,t}$$

where χ is the rate of job destruction.

- The Matching function take V vacants and Ω job seekers as inputs:

$$M_t = M(V_t, \Omega_t)$$

- Then, the probability p_t of find a job in period t is the ratio:

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Employment - Unemployment Transitions

- All new generations are job seekers, so employment state $\Psi_{0,t}$ in the first period of job is

$$\Psi_{0,t} =: \begin{bmatrix} n_{0,t} \\ u_{0,t} \end{bmatrix} = \begin{bmatrix} p_t \\ 1-p_t \end{bmatrix}.$$

- Which describes the transition between states:

$$\Psi_{a,t} = \Phi_{t+a}\Psi_{a-1,t-1},$$

with transition matrix

$$\Phi_{t+a} = \begin{bmatrix} (1-\chi_t)+\chi_t p_{t+a} & p_t \\ \chi_t(1-p_{t+a}) & 1-p_{t+a} \end{bmatrix} \; for\ 0 \leq a \leq \underline{R}-1.$$

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Outline

Households problem

- The problem for each cohort is to maximize welfare

$$W_t^H = \max_{[c_{a,t+a}, s_{a,t+a}]} \sum_{a=0}^{T-1} \left(\frac{1}{1+\theta}\right)^a \beta_{a,t+a} [U(c_{a,t+a}) - d^n n_{a,t+a}] Z_{0,t}$$

- Subject to the intertemporal budget constraint

$$[\overbrace{(1-\tau^w_{t+a})}^{\text{wage taxes}} \overbrace{w_{a,t+a} n_{a,t+a}}^{\text{wages}} \overbrace{+ b^u_{a,t+a} u_{a,t+a}}^{\text{un. insurance}} \overbrace{+ PP_{a,t+a}}^{\text{public+private pensions}}] z_{a,t+a}$$

$$\overbrace{(\check{P}P_{a,t+a} + PP_{a,t+a} + WW_t)(1 - z_{a,t+a})}^{\text{solidarity+public+private pensions}} + \overbrace{\left[\frac{\beta_{a-1,t+a-1}}{\beta_{a,t+a}}\right]^{\omega} R_t s_{a-1,t+a-1}}^{\text{savings returns}} =$$

$$\overbrace{(1+\tau^c_{t+a})}^{\text{cons. taxes}} \overbrace{c_{a,t+a}}^{\text{consumption}} \overbrace{+ s_{a,t+a} + B^H_{a,t+a}}^{\text{current savings}}$$

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Households Problem

- Households will save until welfare of less consumption today equates the gains of more consumption tomorrow:

$$\frac{U'_{c_{a,t+a}}}{1+\tau^c_{t+a}} = \frac{R_{t+a+1}}{1+\theta} \frac{U'_{c_{a+\mathbf{1},t+a+\mathbf{1}}}}{1+\tau^c_{t+a+1}}$$

Outline

Firms

- Aggregate effective labor

$$H_t = \sum_{a=0}^{\overline{R}} h_{a,t} N_{a,t}$$

- Value of the firm

$$W_t^F = \max_{K_t, V_t} \left\{ F(K_t, H_t) - v_t K_t - \sum_{a=0}^{\overline{R}} (1+\xi_t) w_{a,t} N_{a,t} - a V_t \right\} + \frac{W_{t+1}^F}{R_{t+1}}$$

- FOC

$$v_t = F_k, \quad a = q_t \sum_{a=0}^{\overline{R}} \frac{\Omega_{a,t}}{\Omega_t} \frac{\partial W_t^F}{\partial N_{a,t}}$$

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- Pension benefits

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- Total transfer expenditures: "withdrawals"+pensions+Rais Transefers+solidarity

$$T_t = \overbrace{\rho_t v_{a,t}(1 - p^{Pu}_{\overline{R},t})[\tau w]^{Pu}_t}^{"withdrawals"} Z_{\overline{R},t}$$

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- +Solidarity:=$SS_t = \sum_{i=\overline{R}}^{T} \underline{b}_t (1 - \check{p}_{i,t}) Z_{i,t} + \sum_{i=0}^{\overline{R}} b_t^u u_{i,t} Z_{i,t}$
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Government Balance

- Government Balanced Budget (τ_t^c)

$$\tau_t^c C_t + CT_t^{Pu} + RG_t = G_t + T_t + mgf_t$$

$$\text{where } mgf_t = \begin{cases} MGF_t & \text{if } MGF_t \leq 0 \\ 0 & \text{if } MGF_t > 0 \end{cases}$$

Outline

Wages and Capital Market

- Wages are renegotiated every period by a standard Nash bargaining rule

$$\max_{w_{a,t}} \left(\frac{\partial W_t^F}{\partial N_{a,t}} \right)^{1-\eta} \left(\frac{1}{u'_{c_{a,t}}} \frac{\partial W_t^H}{\partial N_{a,t}} \right)^{\eta}$$

- Return on equities must equal the market interest rate (Q_t is total value of firm at t)

$$\frac{Q_{t+1} + \Pi_{t+1}}{Q_t} = R_{t+1}$$

- Then, equilibrium in capital markets is

$$K_{t+1} + Q_t = \sum_{a=0}^{\overline{R}} s_{a,t} Z_{a,t} + F_t + MGF_t$$

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Pension Funds

- Pension funds evolve in accordance with returns, private pensions, withdrawals, contributions, and PAYG transfers

$$F_t = (1 + r_t)F_{t-1} + CT_t^{Pr} - WW_t^{Pr} - PP_t^{k,Pr} + GR_t - RG_t$$

- Minimun Guarantee Fund

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Equilibrium

Definition

Given the demographic and policy variables and the initial population, an intertemporal equilibrium with perfect foresight and labor market frictions is such that:

1. Savings, consumption and retirement decisions maximize households' utility subject to budget constraint
2. Capital, posted vacancies and output maximize Firms profit.
3. The matching technology is satisfied.
4. Wages are negotiated following a Nash bargaining rule.
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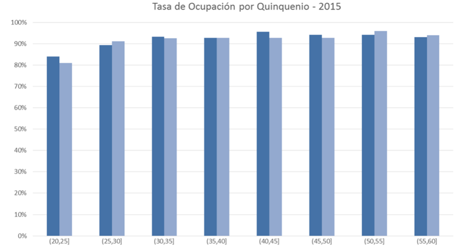
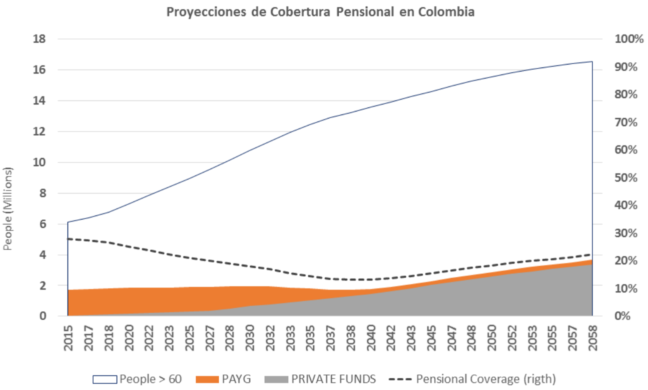
Employment by Age



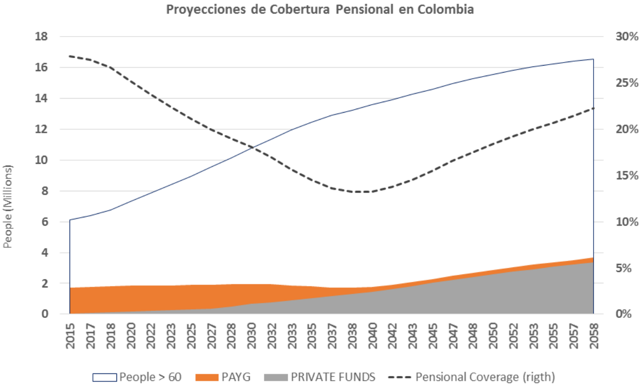
	(20,25]	(25,30]	(30,35]	(35,40]	(40,45]	(45,50]	(50,55]	(55,60]
Datos	84.0%	89.2%	93.3%	92.7%	95.6%	94.1%	94.1%	93.1%
Modelo	80.9%	91.1%	92.5%	92.6%	92.7%	92.7%	96.0%	94.0%

Coverage



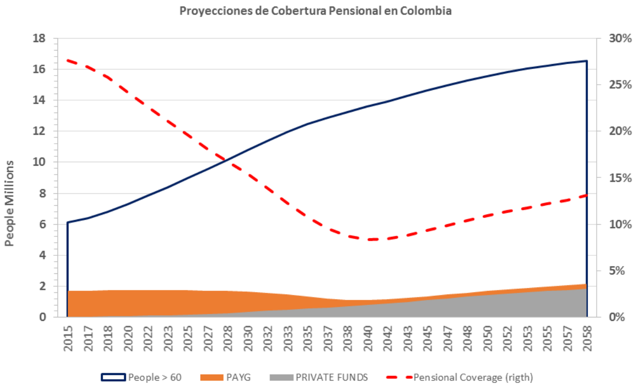
Fuente: Modelo de Equilibrio General–OLG para pensiones MHCP-DGRESS

Coverage



Fuente: Modelo de Equilibrio General–OLG para pensiones MHCP-DGRESS

Coverage: optative MGF



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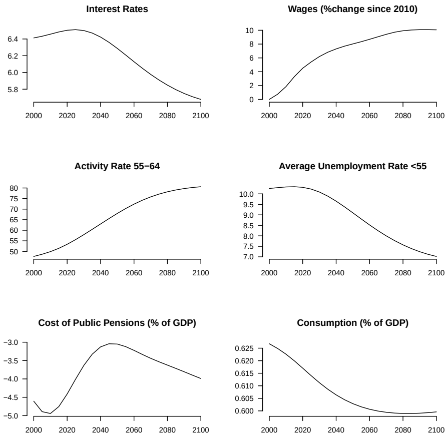
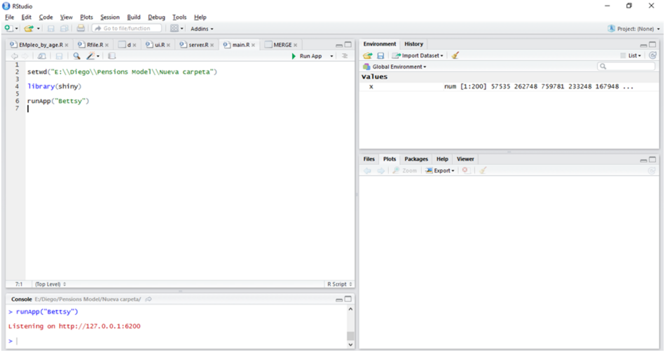
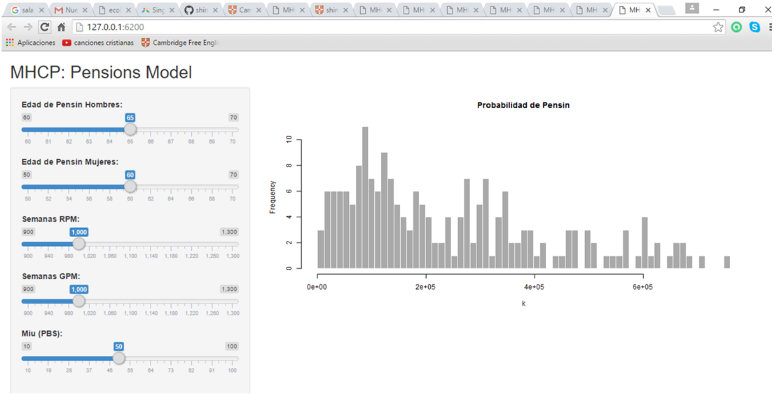
Main economic variables



Shiny app: interactive



Shiny: Retirement Age



Summary

- This macroeconomic framework can be an alternative baseline for a comprehensive fiscal model at MHCP.
- Several kinds of shocks can be modeled to get estimates of key variables.
- Outlook
  - Multiple wage paths
  - Next step could be the Chilean IMF (GIFM) approach.
  - AFPs remuneration incentives.
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  - Aggregate uncertainty.

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