Technical Appendix for *Incentives for Early Retirement and Pension Reform*

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A Detailed Household Problem(s)

The life-cycle of households with heads between the ages of 20 and 99 are separated in three phases: working life, pension eligibility, and retirement. The working life begins at age 20 and lasts until age $j_P - 1$. During this time, households make consumption, labor supply, and savings decisions. Average taxable earnings and years of contributions evolve based upon labor supply decisions during this time. Households become pension eligible at age j_P; this phase lasts until age $j_R - 1$. During the pension eligiibility phase, households will also make a decision of whether to retire. After age j_R, all households are assumed to be retired and households make only consumption and savings decisions.

A.1 Working-Age Households

The problem of a working age ($j = 1, ..., j_P - 1$) household of skill level ε is given by:

$$V_{j,\varepsilon}(a_t, \overline{y}_t, \chi_t; S_t) = \max_{c_t, h_t, a_{t+1}} \left\{ u\left(c_t, l_t\right) + \beta \lambda_{j+1} V_{j+1,\varepsilon}(a_{t+1}, \overline{y}_{t+1}, \chi_{t+1}; S_{t+1}) \right\}$$

subject to

$$\begin{aligned}
\left(1 + \tau_{ct}\right) c_t + \lambda_{j+1} a_{t+1} &= \left(1 + r_t\right) a_t + w_t \varepsilon \left(h_{ft} + h_{it}\right) - T_t^j \left(w_t \varepsilon h_{ft}\right) \\
T_t^j \left(w_t \varepsilon h_{ft}\right) &= \tau_{ht} w_t \varepsilon h_{ft} - \psi^C \\
l_t &= 1 - \Gamma_\varepsilon \left(h_{ft}, h_{it}\right) \\
\overline{y}_{t+1} &= \frac{\left(j-1\right) \overline{y}_t + w_t \varepsilon h_{ft}}{j} \\
\chi_{t+1} &= \begin{cases} \chi_t + 1 & \text{, if } h_{f,t} \geq \underline{h} \\ \chi_t & \text{, if } h_{f,t} < \underline{h} \end{cases}
\end{aligned}$$

A.2 Pension Eligible Households

The problem of a pension eligible ($j = j_p, ..., j_R - 1$) household of skill level ε is given by:

$$V_{j,\varepsilon}(a_t, \overline{y}_t, \chi_t, t_{R,t}; S_t) = \max_{c_t, h_t, a_{t+1}, f_{t+1}} \left\{ u\left(c_t, l_t\right) + \beta \lambda_{j+1} V_{j+1,\varepsilon}(a_{t+1}, \overline{y}_{t+1}, \chi_{t+1}, t_{R,t+1}; S_{t+1}) \right\}$$

subject to

$$\begin{aligned}
\left(1 + \tau_{ct}\right) c_t + \lambda_{j+1} a_{t+1} &= \left(1 + r_t\right) a_t + w_t \varepsilon \left(h_{ft} + h_{it}\right) - T_t^j \left(w_t \varepsilon h_{ft}, \overline{y}_t, \chi_t, t_{R,t}\right) \\
T_t^j \left(w_t \varepsilon h_{ft}, \overline{y}_t, \chi_t, t_{R,t}\right) &= \tau_{ht} w_t \varepsilon h_{ft} - \mathbb{I}\left\{t_{R,t} > 0\right\} \psi^R \left(\overline{y}_t, \chi_t, t_{R,t}\right) - \psi^C \\
l_t &= 1 - \Gamma_\varepsilon \left(h_{ft}, h_{it}\right) \\
\overline{y}_{t+1} &= \begin{cases} \frac{(j-1)\overline{y}_t + w_t \varepsilon h_{ft}}{j} & \text{, if } t_{R,t} = 0 \\ \overline{y}_t & \text{, if } t_{R,t} > 0 \end{cases}
\end{aligned}$$

$$\chi_{t+1} = \begin{cases} \chi_t + 1 & \text{, if } h_{f,t} \geq \underline{h} \\ \chi_t & \text{, if } h_{f,t} < \underline{h} \end{cases}$$

$$t_{R,t+1} = \begin{cases} 0 & \text{, if } t_{R,t} = 0, f_{t+1} = 0 \\ j+1 & \text{, if } t_{R,t} = 0, f_{t+1} = 1 \\ t_{R,t} & \text{, if } t_{R,t} > 0 \end{cases}$$

A.3 Retired Households

The problem of a retired ($j = j_R, ..., J$) household of skill level ε is given by:

$$V_{j,\varepsilon}(a_t, \overline{y}_t, \chi_t, t_{R,t}; S_t) = \max_{c_t, h_t, a_{t+1}, f_t} \left\{ u\left(c_t, l_t\right) + \beta \lambda_{j+1} V_{j+1,\varepsilon}(a_{t+1}, \overline{y}_{t+1}, \chi_{t+1}, t_{R,t+1}; S_{t+1}) \right\}$$

subject to

$$\begin{aligned} \left(1 + \tau_{ct}\right) c_t + \lambda_{j+1} a_{t+1} &= \left(1 + r_t\right) a_t + w_t \varepsilon \left(h_{ft} + h_{it}\right) - T_t^j \left(\overline{y}_t, \chi_t, t_{R,t}\right) \\ T_t^j \left(\overline{y}_t, \chi_t, t_{R,t}\right) &= -\psi^R \left(\overline{y}_t, \chi_t, t_{R,t}\right) - \psi^C \\ l_t &= 1 - \Gamma_\varepsilon \left(h_{ft}, h_{it}\right) \\ \overline{y}_{t+1} &= \overline{y}_t \\ \chi_{t+1} &= \chi_t \\ t_{R,t+1} &= t_{R,t} \end{aligned}$$

B Definition of the Equilibrium on a Balanced Growth Path

An equilibrium is given by government policies, a tax rate on consumption, τ_c, a labor income tax, τ_h, a tax rate on corporate profits, τ_p, a tax rate on firm dividends, τ_d, transfers, T^j and ψ, and debt and government spending, B and G; an interest rate r and wage w; value functions, $V_\varepsilon(a, \overline{y}, \chi, t_R; S)$; and allocations, $c_\varepsilon(a, \overline{y}, \chi, t_R; S)$, $a'_\varepsilon(a, \overline{y}, \chi, t_R; S)$, $h_f^\varepsilon(a, \overline{y}, \chi, t_R; S)$, $h_i^\varepsilon(a, \overline{y}, \chi, t_R; S)$ such that:

1. Given the government policies, interest rate, and wage rate, the value functions and allocations solve the agent's maximization problem for the indivisual state variables, a, $\overline{y}$, χ, and t_R, and aggregate state variables S
2. Given the government policies and prices, the firm optimizes
3. The government budget constraint holds in each period
4. All markets clear

$$K_m = \sum_{j,\varepsilon} \mu^{j,\varepsilon} a^{j,\varepsilon} - B$$

$$C = \sum_{j,\varepsilon} \mu^{j,\varepsilon} c^{j,\varepsilon}$$

$$H_f + H_i = \sum_{j,\varepsilon} \mu^{j,\varepsilon} (h_f^{j,\varepsilon} + h_i^{j,\varepsilon})\varepsilon$$

$$X = K_m^{'} - (1-\delta)K_m$$

$$f\left(K_m, H_f + H_i\right) = Y = C + X + G$$

Then, assuming that the capital and labor markets clear, it must also be the case that the household policy functions, $\left\{a' = g_j^a\left(S,\varepsilon\right)\right\}_j$, $\left\{h_f = g_j^h\left(S,\varepsilon\right)\right\}_j$, and $\left\{f = g_j^r\left(S,\varepsilon\right)\right\}_j$ imply the aggregate law of motion $S' = G\left(S\right)$, where the function G is taken as given by the private agents.

C Computational Details

The algorithm is described for one productivity type. This is done to simplify notation. The algorithm can be expanded to handle additional productivity types. Section C.1 discusses the algorithm used to solve the model in a balanced growth path.Section C.2 discusses the necessary changes to extend this algorithm to solve the demographic transition path.

C.1 Balanced Growth Path

I will find a fixed point in the interest rate, i, and the common transfer, ψ^c, using functional iteration.[1]

$$x^{k+1} = \omega x^k + (1-\omega)\left[x^k - \mathbb{R}\left(x^k\right)\right]$$

where x^k represents the k-th iteration of the unknown variables, $\omega \in [0,1]$ is a weighting parameter to help with convergence, and $\mathbb{R}\left(x^k\right)$ represents the first order conditions that must by satisfied by the choice of the unknown variables. In the context of this model, these first order conditions are the return to capital being equal to the marginal product of capital[2], $\mathbb{R}_1$ and the government budget constraint, $\mathbb{R}_2$.

Steps of Solution

[1] Can be replaced with Newton-Rhapson. In NR is used to find the fixed point using the following equation

$$x^{k+1} = \omega x^k + (1-\omega)\left(\left[\frac{\partial \mathbb{R}(x)}{\partial x}\mid_{x^k}\right]^{-1} \mathbb{R}\left(x^k\right)\right)$$

[2] Could be replaced by the market clearing condition for market capital

1. Make an initial guess

   set the interest rate, i, as the first element of the guess and the per-capita transfer, ψ^c as the second element of the guess

   - From the firm problem in which firms maximize the discounted value of after-tax dividends, the interest rate is equated to the after-tax return on market capital net of depreciation

$$i = (1 - \tau_p)(r_m - \delta)$$

   Use this to calculate the market capital rental rate, r_m

$$r_m = \frac{i}{1 - \tau_p} + \delta$$

   - Using the optimality conditions from this firm problem, the market capital share and the return to market capital can be used to derive the ratio of capital stock to compensation

$$\frac{K_m}{w(H_f + H_i)} = \frac{\alpha}{(1 - \alpha) r_m} \tag{1}$$

   Then solve for the ratio of Y to $w(H_f + H_i)$

$$\frac{Y}{w(H_f + H_i)} = \frac{A(K_m)^{\alpha}(H_f + H_i)^{1-\alpha}}{w(H_f + H_i)} = \frac{A(K_m)^{\alpha}(H_f + H_i)^{1-\alpha}}{w(H_f + H_i)^{\alpha}(H_f + H_i)^{1-\alpha}}$$

$$\frac{Y}{w(H_f + H_i)} = A\left[\frac{K_m}{H_f + H_i}\right]^{\alpha}\left[\frac{1}{w}\right]^{1-\alpha}$$

$$\frac{Y}{w^{\alpha}(H_f + H_i)} = A\left[\frac{K_m}{H_f + H_i}\right]^{\alpha} \tag{2}$$

$$\frac{Y}{(H_f + H_i)} = Aw^{\alpha}\left[\frac{K_m}{H_f + H_i}\right]^{\alpha}$$

   Because of PC in the market, $w = (1 - \alpha) MPL$

$$w = (1 - \alpha) Aw^{\alpha}\left[\frac{K_m}{w(H_f + H_i)}\right]^{\alpha}$$

$$w = \left[(1 - \alpha) A\left(\frac{K_m}{w(H_f + H_i)}\right)^{\alpha}\right]^{\frac{1}{(1-\alpha)}} \tag{3}$$

   Additionally,

$$\frac{K_m}{H_f + H_i} = \frac{K_m}{w\left(H_f + H_i\right)} \cdot w$$

$$\frac{Y}{\left(H_f + H_i\right)} = \frac{Y}{w^{\alpha}\left(H_f + H_i\right)} \cdot w^{\alpha}$$

2. Solve the household problem for each point of the asset grid $a \in [0, \bar{a}]$, the grid of average annual taxable earnings $\overline{y} \in [0, \hat{y}]$, and the grid of contributions $\chi \in [1, \hat{\chi}]$
   (a) Set $V_{J+1} = 0$ and solve the value function for each point of the individual state grid
   (b) By using backward induction, repeat step 2 for $j = J - 1, ...1$. This involes working through the various life-stages as discussed in section A.
      i. Iteratively solve the value function
      ii. At each step j, store the optimal decision functions
3. Compute the distribution of households by forward induction using the policy functions
4. Aggregate optimal choices for:
   (a) Consumption C
   (b) Formal hours H_f
   (c) Informal hours H_i
   (d) Assets A
5. Multiply $\frac{Y}{\left(H_f + H_i\right)}$ by $\left(H_f + H_i\right)$ to solve for total output
6. Define the aggregate market capital stock as the

$$A = V + B = V + \phi_B GNP = V + \phi_B Y$$

$$V = A - \phi_B Y$$

$$\left(1 - \tau_d\right) K_m = A - \phi_B Y$$

$$K_m = \frac{A - \phi_B Y}{\left(1 - \tau_d\right)} \tag{4}$$

7. Define investment. This definition is due to the fact that we are on a balanced growth path.

$$X = \left[(1 + \eta) - 1 + \delta\right] K_m \tag{5}$$

8. Construct the analogues of GNP, accounting profits, and corporate dividends

$$GNP = Y \tag{6}$$

$$\Pi = Y - w\left(H_f + H_i\right) - \delta K_m \tag{7}$$

$$\Delta = Y - w\left(H_f + H_i\right) - X - \tau_p \Pi \tag{8}$$

9. Use GNP to construct the other variables for the government budget constraint

$$G = \phi_G GNP = \phi_G Y \tag{9}$$

$$B = \phi_B GNP = \phi_B Y \tag{10}$$

$$T = \sum_{j,\varepsilon} \mu^j T^j \left(w \varepsilon h_f\right) \tag{11}$$

10. Check the market clear condition and government budget constraint

$$\mathbb{R}_1\left(x\right) = r_m - \alpha \frac{Y}{K_m} \tag{12}$$

$$\mathbb{R}_2\left(x\right) = T + G - \tau_h H_f - \tau_p \Pi - \tau_d \Delta - B^{'} + \left(1 + i\right) B - \tau_c C_m \tag{13}$$

11. If these conditions hold, an equilibrium is found. If not, update the initial guess and start again at step 1

C.2 Transition Path

Solving for the transition path is similar to the balanced growth path process described above. Particularly, the household problem is solved for each birth-year cohort. However, now I must keep track of time series for the unknown variables throughout the transition path. This is required as each cohort will face different prices and policies associated with where they are in the transition path between the steady states.

In additional to the unknown variables from the balanced growth path, wage is added as an unknown. This is because I can no longer solve for these variables in terms of other known variables. Specifically, an additional condition is added to the vector, $\mathbb{R}\left(x\right)$:

$$\mathbb{R}_3\left(x\right) = w - \left(1 - \alpha\right) \frac{Y}{\left(H_f + H_i\right)} \tag{14}$$

The computation of the transition path is performed through utilization of parallel processing. Solving the problem is separated onto N different processors. Each processor n is assigned $\frac{T_{max}}{N}$

cohorts for which to solve the life cycle problem, where T_{max} is the total number of time periods over which the transition path is solved. Once each processor n solves the problems of their assigned cohorts, the results are collected onto a single processor in order to calculate the aggregates at each time period of the transition path and the associated prices at those time periods. Important in the calculation of these aggregates is that different points in the transition are associated with different demographics.

D Fiscal Policy Series and Government Policy Parameters

Consumption Taxes

Indirect taxes in Brazil is very complicated. Here, I will focus on the state sales tax, ICMS, which is a tax on the circulation of goods and transportation and communication services.

The ICMS standard rate is 17%. It has a rate of 18% in Sao Paul, Minas Gerais, and Parana states and a rate of 19% in Rio de Janeiro.

Other Indirect Taxes

- IPI: a federal excise tax

  The IPI is normally charged at an ad valorem rate according to the classification of the goods based on the internation harmonized commodity descroption and coding systems. The rates range from 0% to 330% with an average rate of 10%

- ISS: municipal services tax which ranges from 2% to 5%

- COFINS: social contribution for social security financing (7.6%)

- PIS: employees' profit participation program (1.65%)

Labor Income Taxes

Brazil has a progressive personal income tax system. The rate ranges from 0 to 27.5% of personal income. Table 2 shows the rates for various income levels.

Corporate Taxes

A corporate income tax is levied on taxable profits of an entity at a rate of 15%. There is also a 10% surtax imposed on taxable income above 240,000 BRL in annual income. There is an additional 9% added for social contributions on net profits.

Fiscal Series

As mentioned in the text, I take the values for government debt and government spending from 2018, and I assume these values remain constant throughout the transition path. In 2018, government debt was 77.22 percent of GDP and government spending on defense was 1.4 percent of GDP. These values are used in the analysis. Future iterations will also include transfers to households for other social spending from the government. This version assumes that this spending is 0.

Table 1: Social Security Tax Rates

Before Reform (2015)		After Reform (2021)	
Monthly Income (BRL)	Tax Rate	Monthly Income (BRL)	Tax Rate
$\leq$ 1,556.94	8%	$\leq$ 1,100	7.5%
1,556.94-2,594.92	9%	1,100.01-2,203.48	9%
2,594.92-4,390.24	11%	2,203.49-3,305.22	12%
4,390.24	11%	3,305.22-6,433.57	14%
		6,433.57	14%

Notes: The year 2015 is shown as this is the year used in PNAD.

Table 2: Personal Income Tax Rates (2017)

Monthly Income (BRL)	Tax Rate
$\leq$ 1,903.98	0%
1,903.99-2,826.65	7.5%
2,826.66-3,751.05	15%
3,751.06-4,664.68	22.5%
> 4,664.68	27.5%

Table 3: Sample Selection

	No. of Households	No. of Individuals
Total Sample	92,527	226,226
Head between ages 20 and 55	58,393	135,673
Head worked more than 50 market hours	57,357	133,717

E Estimation of Market Labor Supply Parameters

This section deals with the estimation of the parameters which govern the levels and substitutability of formality and informality. Specifcally, this section details the estimation of Equation 15.

$$\ln\left[\frac{h_f}{h_i}\right] = \beta_0 + \beta \ln\left(1 - \tau_h\right) + \varepsilon \tag{15}$$

where $\beta_0 = \frac{1}{b_\varepsilon - 1} \ln\left[\frac{1-a_\varepsilon}{a_\varepsilon}\right]$ and $\beta_1 = \frac{1}{b_\varepsilon - 1}$

E.1 Data and Sample

Data for the estimation is from Pesquisa Nacional por Amostra de Domicilios (PNAD). PNAD is a national survey of Brazilian households which has been collected since 1981 and contains demographic and employment information for respondents. For this work, the year 2015 is used in the estimation. The 2015 sample includes data for 117,939 households and 356,904 individuals. This works uses a sub-sample of these households and household members. in order to estimate the parameters related to market–formal and informal–labor supply.

The first step in cleaning the data is to gather individuals into households. Only those household members between the ages of 15 and 70 are kept in order to focus on those household member who are of working age and may contribute to the household income and labor supply decisions. Also, those who do not work or report working more than 400 hours monthly are dropped. Finally, those in household members in the top and bottom 1 percent of income are dropped.

Hours and income of each individual are classified as formal or informal based upon the sector worker in and whether the worker reports working legally or contributing to a pension system. If an individual works in the public sector, hours and income are classified as formal. If the individual works in the private sector hours and income are classified as formal if the worker is legally employed and/or contributes to a pension plan. If the worker reports being illegally employed, hours and income are classifed as informal. Labor income tax and Social Security contribution rates are calculated at the individual level based upon individual formal income. These individuals are then aggregated to the household level. Total household hours and income are the sum of each individual's hours and income. Household tax rates are constructed by taking the income weighted average of marginal tax rates faced by each individual.

Table 4: Sample Summary Statistics

	Household Head	Other Family Members
Age	39.50	35.00
	(0.045)	(0.047)
Share with $>$ 12 years of education	21.7	21.7
Share Male	70.6	52.9
Family Size	2.33	
	(0.005)	
Household Hours (monthly)		
Total	272.75	
	(0.715)	
Formal	196.26	
	(0.907)	
Income	76.49	
	(0.669)	
Household Income (BRL monthly)		
Total	3,163.34	
	(30.317)	
Formal	2,571.14	
	(29.75)	
Income	592.20	
	(7.232)	

Once individuals are organized into households, the final sample is selected based upon characteristics of the head of household. Table 3 shows the sample size, both the number of households and the total number of individuals, in the total sample and at each level of sample selection. The total sample includes 92,527 households covering 226,226 individuals. I focus on those observations with heads of household between the ages of 20 and 55. This criteria is put in place to focus the analysis on working age individuals. Because of the prevalence of early retirement in Brazil this forces me to look to age 55 rather than 65 which is more common in other analyses. This decreases the sample to 58,393 households and 135,673 individuals. Finally, I focus on those households in which the household head works more than 50 hours in the month. This criteria is to limit those households who may be unemployed and receiving other income support programs. Since these are not modeled, they are excluded from study. This leaves a final sample of 57,357 households covering 133,717 individuals.

Table 4 shows some summary statistics about the sample. On average, a household is 2.33 persons. Household heads have an average age of roughly 40 while other household members

have average ages around 35. Around 20 percent of both household heads and other household members have strictly greater than 12 years of education. Heads are 70 percent male while other family members are around 50 percent male. Households work about 275 hours per month and earn around 3,000 BRL monthly. The majority of both hours and income come from the formal sector.

E.2 Baseline Estimation

Equation 15 is estimated on the sample discussed above. There are two issues with this estimation which should discussed.

First, because the regression equation is log-linear, estimation only uses interior observations, or observations in which the household works strictly positive hours in both the formal and informal sectors. 18.7 percent of the sample satisfies this. However, as discussed in McKiernan (2021), the interior solution households are those which ae most likely to move between sectors in response to policy or other forces. Therefore, this estimation focuses on those households. To get an idea of how much these corner solutions are impacting the estimates, I look more into this in Section E.3.3.

Related to the issue above is the impact on outliers on the estimation. Within the 18.7 percent of the sample which has positive hours in both sectors, there are outliers which record a very high ratio of formal hours to informal hours. The small number of high values is likely to bias the estimates of the preference parameters. This is especially likely for high income individuals as they are most likely to have these outliers. In order to correct for this, I drop those observations in which the ratio of formal hours to informal hours is in the top 1 percent of observations. This drops observations in which the ratio of formal hours to informal hours is above 8.3. These observations will be considered again in Section E.3.3.

Second, it is possible that the labor income tax influenced by things such as the type of job held or other characteristics. In order to combat this, I include various control variables in the regression equation including a polynomial in the age of the household head, a polynomial in the average age of household members, the education level of the household head, the education level of other household members, an interaction between the two education levels, and a control for the numer of family members in the household. Because the data used is cross-sectional, there is no way to appeal to panel data techniques. Regression results without these control variables is show in E.3.1

Results from the baseline regression are shown in 5. Table 8 shows the structural parameters derived from these coefficients. These are the parameter values shown in Table 2 of the main text.

E.3 Sensitivity

E.3.1 No Controls

Control variables, including age, education, and number of household members, are included to control for characteristics that may be correlated the ratio of formality and informality as well as the tax rate. Tables 7 and 8 show the regression results and parameter values, respectively, for the estimation which excludes these controls.

Table 5: Baseline Regression Results

	public sector	private sector		
		$\leq 2,000$ BRL	$2,000 - 4,000$ BRL	$> 4,000$ BRL
$\ln(1-\tau_h)$	-2.012^{***}	-42.90^{***}	-1.749^{***}	-0.673^{***}
	(0.131)	(7.313)	(0.258)	(0.116)
constant	-0.169	-14.22^{***}	-0.352	0.881
	(1.348)	(2.528)	(1.013)	(1.732)
Observations	2,413	2,247	3,125	1,454
R-squared	0.134	0.045	0.037	0.075
Controls				
HH head age	YES	YES	YES	YES
HH member age	YES	YES	YES	YES
HH head education	YES	YES	YES	YES
HH member education	YES	YES	YES	YES
number of family members	YES	YES	YES	YES

Notes: Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.01

Table 6: Baseline Parameter Values

	public sector	private sector		
		$\leq 2,000$ BRL	$2,000 - 4,000$ BRL	$> 4,000$ BRL
a	0.479	0.418	0.450	0.787
	(0.167)	(0.005)	(0.143)	(0.430)
b	0.503	0.977	0.428	-0.486
	(0.032)	(0.004)	(0.084)	(0.256)

Notes: Standard errors in parentheses.

Table 7: Regression Results with No Controls

	public sector	private sector		
		$\leq 2,000$ BRL	$2,000 - 4,000$ BRL	$> 4,000$ BRL
$\ln(1-\tau_h)$	-1.877^{***}	-42.43^{***}	-1.638^{***}	-0.203^{*}
	(0.109)	(7.639)	(0.256)	(0.106)
constant	-0.274^{***}	-13.66^{***}	-0.327^{***}	0.227^{***}
	(0.026)	(2.511)	(0.091)	(0.061)
Observations	2,413	2,247	3,125	1,454
R-squared	0.100	0.013	0.018	0.003
Controls				
HH head age	NO	NO	NO	NO
HH member age	NO	NO	NO	NO
HH head education	NO	NO	NO	NO
HH member education	NO	NO	NO	NO
number of family members	NO	NO	NO	NO

Notes: Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.01

Table 8: Parameter Values with No Controls

	public sector	private sector		
		$\leq 2,000$ BRL	$2,000 - 4,000$ BRL	$> 4,000$ BRL
a	0.464	0.420	0.389	0.753
	(0.002)	(0.000)	(0.095)	(0.430)
b	0.467	0.976	0.450	-3.92
	(0.031)	(0.004)	(0.006)	(0.256)

Notes: Standard errors in parentheses.

Table 9: Aggregated Regression Results

	aggregate	public sector	private sector
$\ln(1-\tau_h)$	-0.769^{***}	-2.012^{***}	-0.531^{***}
	(0.058)	(0.131)	(0.094)
constant	-0.077	-0.169	-0.258
	(0.578)	(1.348)	(0.680)
Observations	10,497	2,413	6,826
R-squared	0.033	0.134	0.018
Controls			
HH head age	YES	YES	YES
HH member age	YES	YES	YES
HH head education	YES	YES	YES
HH member education	YES	YES	YES
number of family members	YES	YES	YES

Notes: Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.01

Overall, the results are very similar to the baseline case. The only big difference between the estimations shows up in the substitutability parameter, b, in the case of the highest income private sector workers. While both estimations yield a negative estimate for b, the case of no controls leads to a much more negative value. The baseline estimation highlights that the sectors are more complementary for high income workers; the estimation without controls shows these sectors to be nearly perfect complements for these workers.

E.3.2 Aggregation

The baseline results separate the individuals into productivity groups based on income and sector worked. The preference parameters which govern the substitution between formality and informality are estimated separately for each of these productivity groups. In this section, present results at higher levels of aggregation. Specifically, I show the regression results and parameter estimates for all individuals together, public sector only (shown as one of the groups in the baseline estimation), and private sector only. These results are shown in Tables 9 and 10.

These results show that these parameters are very different when the heterogeneity is ignored. When we consider private sector only or all individuals together the substitutability parameter, b, becomes negative. When the heterogeneity is considered, this value is negative only for the highest income private sector workers. This results that ignoring the heterogeneity cloaks differences in the trade offs between formality and informality for Brazilian workers.

Table 10: Aggregated Parameter Values

	aggregate	public sector	private sector
a	0.475	0.479	0.381
	(0.187)	(0.167)	(0.304)
b	−0.301	0.503	−0.885
	(0.097)	(0.032)	(0.333)

Notes: Standard errors in parentheses.

E.3.3 Include corner solutions

As discussed, the baseline estimation does not consider corner solutions, or workers who work only in one sector or the other. In this section I propose and estimate the preference parameters related to formality and informality with the corner solutions. This method includes two steps which differ from previous estimations. First, I do not drop those outlier observations with high values for the ratio of formal to informal hours. Second, any observations with a value of 0 hours for either sector is assigned 1 hour in that sector. Therefore, rather than having values of the ratio of formalit to informality which are 0 or undefined, these observations will have ratios which are either very small or very large. While a more sophisticated estimation procedure would handle these corner solutions in a more eloquent way, this exercise will give an idea of how these corner solutions–or the exclusion of these corner solutions–changes the estimates. The results of this estimation are shown in Tables 11 and 12.

Overall, including the outlier and corner solutions increases both the share of formal hours and the subsitutability between formality and informality. The majority of corner solutions are those households who work entirely in the formal sector. Therefore, the inclusion of both these and the large outliers increase the share of formal hours relative to informal hours. Additionally, the substitutability also increases because this estimation includes workers that have revealed that formality and informality are perfectly substitutable to them. As perfect substitutability is associated with a value of $b = 1$, this drives up the substitutability for all groups. Because high income, private sector workers had the highest number of worker dropped due to the corner solutions, the movement in subsitutability for this group is large and moves the sectors from complements $(b < 0)$ to substitutes $(b > 0)$.

F Life-Cycle Labor Productivity

Labor productivity profiles are estimated as a function of age using the regression in Equation 17.

$$\ln w_j = f_\varepsilon(j) + \beta x_j' + u_j \tag{16}$$

where$f(j)$ is a (possibly income group specific) polynomial in the age of the head of household and x_j is a vector of control variables including a polynomial in the average age of other household members, the education of the household head, the education of the other household

Table 11: Regression Results with Corner Solutions

	public sector	private sector		
		$\leq 2,000$ BRL	$2,000 - 4,000$ BRL	$> 4,000$ BRL
$\ln(1-\tau_h)$	-4.371^{***}	-4.253^{***}	-2.207^{***}	$-.1352^{***}$
	(0.145)	(0.236)	(0.274)	(0.273)
constant	7.316^{***}	4.807^{***}	5.316^{**}	4.635
	(1.897)	(1.258)	(2.063)	(3.892)
Observations	11,552	11,408	9,855	4,821
R-squared	0.141	0.165	0.060	0.073
Controls				
HH head age	YES	YES	YES	YES
HH member age	YES	YES	YES	YES
HH head education	YES	YES	YES	YES
HH member education	YES	YES	YES	YES
number of family members	YES	YES	YES	YES

Notes: Standard errors in parentheses. ***p<0.01, **p<0.05, *p<0.01

Table 12: Parameter Values with Corner Solutions

	public sector	private sector		
		$\leq 2,000$ BRL	$2,000 - 4,000$ BRL	$> 4,000$ BRL
a	0.842	0.756	0.918	0.969
	(0.058)	(0.056)	(0.077)	(0.090)
b	0.771	0.765	0.547	0.260
	(0.008)	(0.013)	(0.056)	(0.149)

Notes: Standard errors in parentheses.

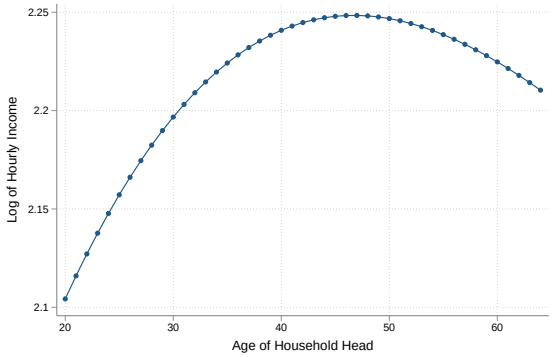
members, controls for the number of formal and informal hours worked, an indicator if the head of household is female, and a control for the number of family members living in the household. I also include interactions between education levels of the household head and household members and between the formal and informal hours worked. u_j is the error term.

This regression is estimated on a sample of households with heads between the ages of 20 and 65 the the 2015 waves of PNAD. The sample includes 69,263 households.

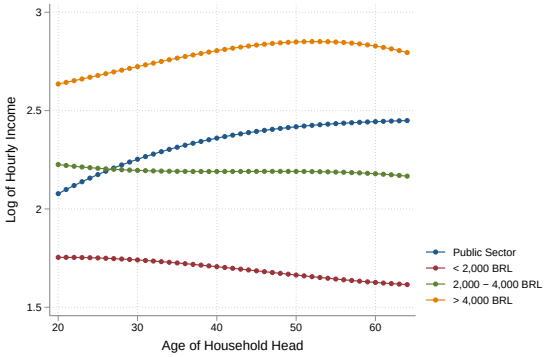
The estimated labor productivity profile is shown in 1a. This profile features the standard hump-shape shown in much previous research. Labor productivity increases steeply early in the career, peaks around age 45 and then decreases until age 65. Figure 1b shows these profiles when the age polynomial is also interacted with the fixed productivity type. There is substantial variation in these profiles by productivity type. However, it is unclear if there profiles are impacted by selection. For this reason, I used a fixed profile for all types. In sensitivity analysis, I consider the impact of the reform if productivity varied by income group.

Figure 1: Life-Cycle Productivity

(a) Aggregate



(b) By Income Group



Impacts of these income group specific life-cycle productivity profiles are detailed in sensitivity analysis.

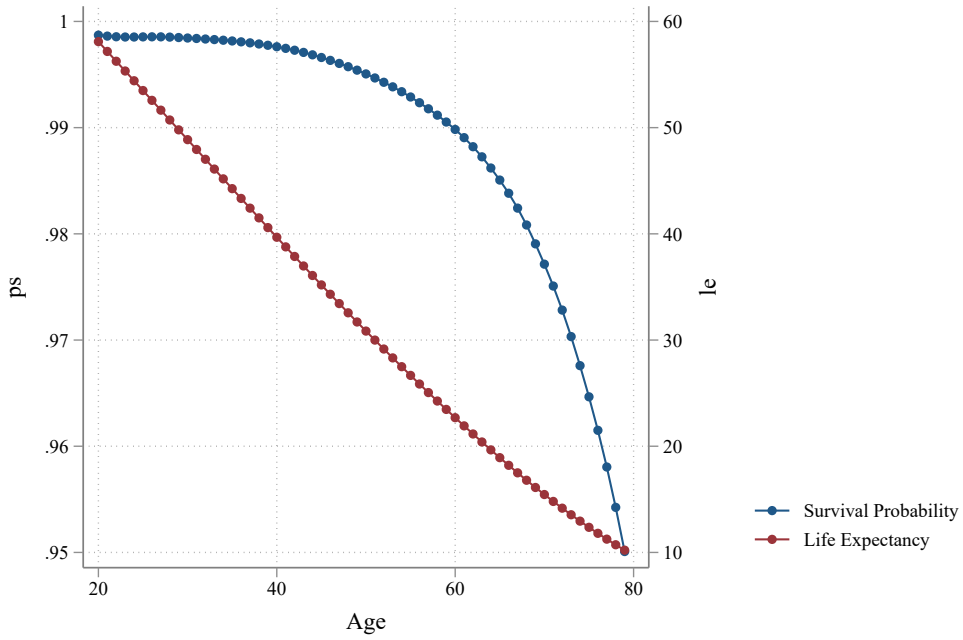
G Demographics

The probability of survival and the life expectancies from the Brazilian life tables are shown in Figure 2. These show that probabilities of survival as well as life expenctancies are decreasing in age. Survival probabilities are used as inputs into the household problem as well as in the caluclation of population dynamics; life expectancies are used in the caluclation of the pension formula (before the reform).

H More on Aggregate Hours

In the calibration, the utility weight on consumption and the discount rate are used to jointly target aggregate hours worked and the capital to output ratio, respectively. The presence of the informal sector in the Brazilian economy brings into question whether the aggregate hours reported

Figure 2: Demographics



represent the total hours (both formal and informal) or just aggregate hours worked in the formal sector. In 2015, Brazil reported 1,723 annual hours per engaged worked or around 33 hours per week (Source: FRED). In order to test the assumption othat it is more natural to target formal hours, I compare this number with average total hours and average formal hours worked in the 2015 PNAD. This dataset reports average formal hours worker per worker as 1,381 hours annually or roughly 27 hours weekly. This results indicate that some portion of informal hours are included in the aggregate measure reported in FRED.

I Aggregates

Figure 3 shows how various macroeconomic aggregates evolve throughout the demographic transition path associated the case of no reform and the case of the passed reform. These values are shown relative to before the reform. Therefore, I interpret these as percentage point changes.

In the long-run, the capital stock (shown in Figure 3b) increases both with and without the reform. Capital stock in these economies increase 10 percent in the case without a reform and 12 percent in the case of the reform. These increases reflect the aging of the population. Workers increase savings throughout their life-cycle and, due to the mortality risk they face, do not draw assets down to 0 prior to death. Therefore, as the population ages, the mass of the population moves to a portion of the life-cycle with higher savings. This occurs with and without the reform. When the reform occurs, however there is heterogeneity in responses. The richest individuals decrease their savings in response to the higher pension they will receive in retirement. The middle-income workers, however, increase savings since they work long but do not get a higher pension. Since middle-income workers represent a larger portion of the population this the capital stock slightly

higher in the case of the reform.

In contrast to the capital stock, labor supply falls throughout the transition as the population ages. The evolutions of formal labor and informal labor are shown in Figures 3c and 3d, respectively. Both labor supplies, however, fall much more in the case of no reform. Without the reform, both labor suppliese fall 16 percent in the long-run. The increased retirement age along a higher wage and pension benefits in the case of the reform means that labor does not fall as much when the reform is enacted. Formal labor supply falls by 10 percent while informal labor falls by 13 percent. In contrast to the case of no reform in which both formal and informal labor fall by the same amount. The increase in contribution rates (and thus labor taxation) changes the trade-off between formality and informality for the household. This leads informality to fall by more than formality.

The increase in capital stock and the decrease in labor supply push overall output in opposite directions. Figure 3a includes the evolution of the capital stock throughout the transition path. However, in both the case of no reform and the case of reform, the decrease in the labor supply overwhelms the increase in capital stock to push output down. Output decreases 8 percent in the case of no reform and only 4 percent in the case of the reform. Because the reform leads to larger increases in capital stock and smaller decreases in the labor supply, the impact on output is smaller in the case of the reform than without the reform.

Productivity, as shown in Figure 3e, is defined as the ratio of output to labor. In both cases, productivity increases–8 percent if the reform does not occur and 10 percent if the reform occurs. Output and labor supply both decrease through the transition path whether the reform occurs or not. Since labor supply decreases by more than output, productivty increases.

J More on Decomposing the Reform

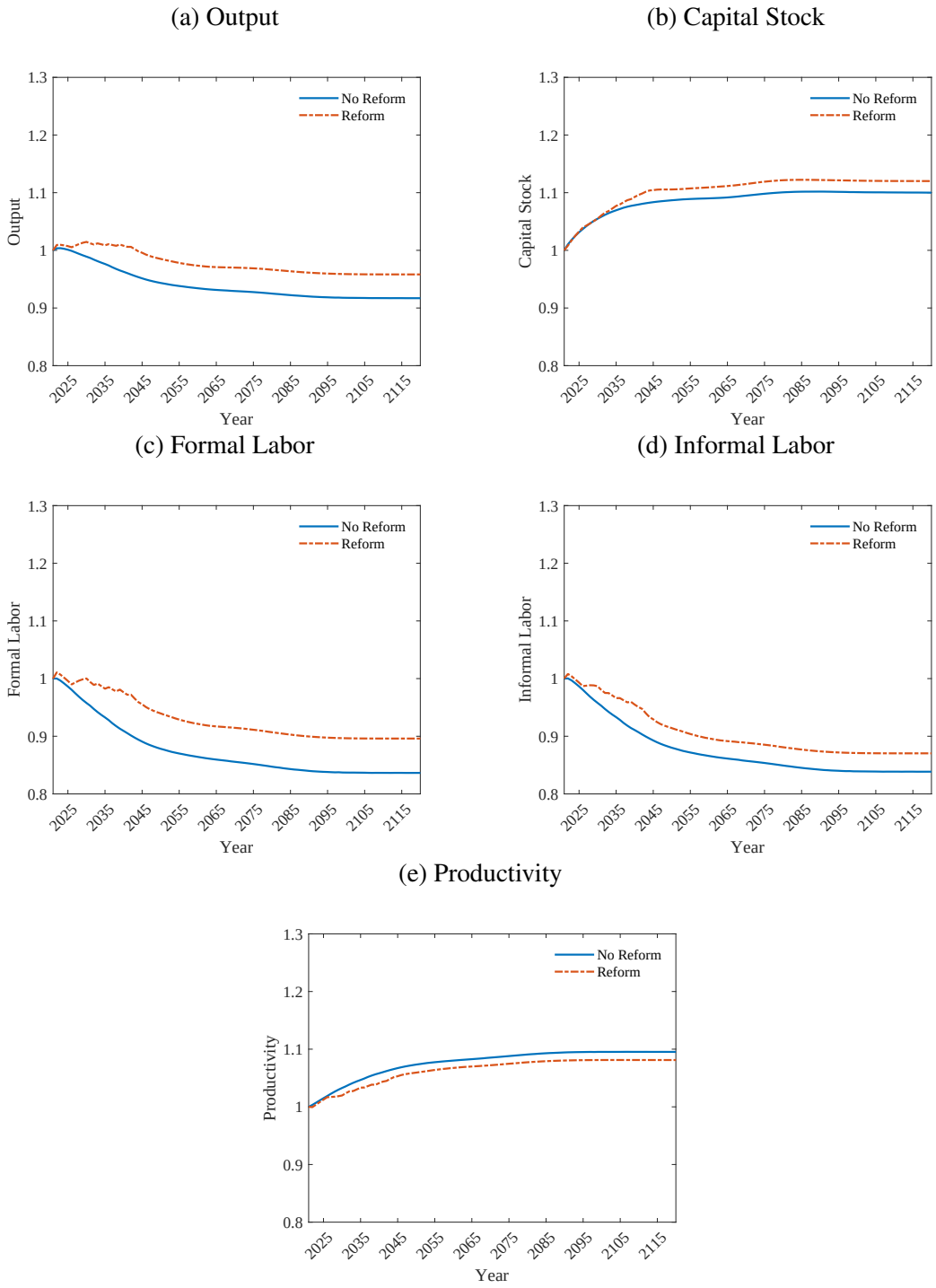
The 2019 Brazilian reform included two main changes. First, the reform increased the minimum age at which a worker is pension eligible by eliminating the path to benefits through years of contributions. Second, the reform changes the pension formula. In this section, I present additional results on the impact of reforms which include only one of these mechanisms. I first present the results for a reform in which the statutory retirement age increases by the pension formula remains the same as before the reform (shown in Section J.1). Then, I show the impact of a reform in which the pension formula changes but the path to benefits through years of contributions remains entact (shown in Section J.2).

J.1 Increasing Only the Statutory Retirement Age

In this section, I consider a reform in which the path to retirement through contributions is eliminated but the pension formula changes as in the 2019 reform. This leads to increases in the statutory retirement age without any changes to the pension received.

Labor Supply Figure 4 shows the labor supply response to this reform; Figure **??** shows the evolution of retirement age while Figure **??** shows the impact of the reform on the years of contributions of these households. As in the main reform, the retirement age of the highest-income households increased from 56 years old to the new statutory retirement age of 65 years old. As

Figure 3: Aggregates: Baseline

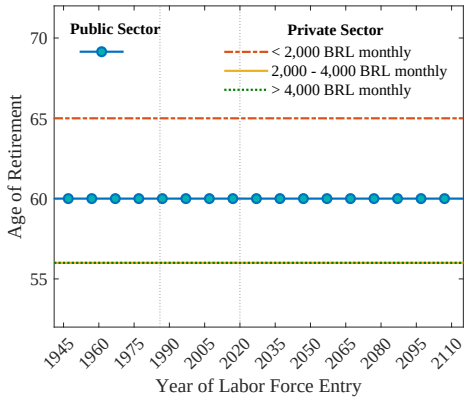


Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.

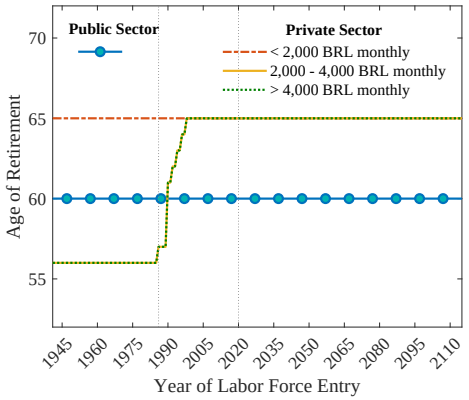
in the baseline results, the retirement age of public sector workers and low-income private sector workers is unaffected by the reform. Increasing only the retirement does, however, have an impact on the years of contributions of the households. The contributions of middle- and high-income households are impacted by the change in policy; middle-income households decrease years of contributions from 35 years to 32 years while high-income workers increase their contributions from 35 to 44 years. The longer working lives allows high-income workers to maximize their years of contributions. Falling labor supply throughout the transition, however, leads these households to fall beneath the threshold, $\underline{h}$, to qualify as contributing. This lead their contributions to fall slightly. Despite falling labor supply, high-income workers continue to keep formal participation above this threshold and accumulate additional years of contributions.

Figure 4: Retirement Age and Years of Contributions by Cohort: Increase Only Statutory Retirement Age

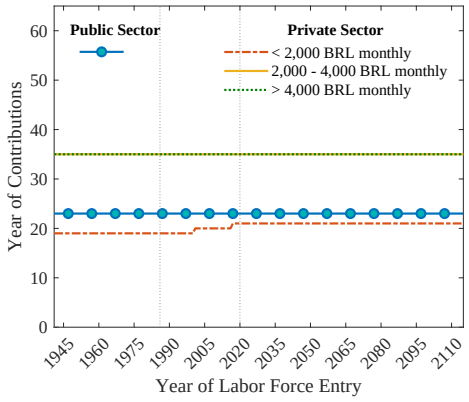
(a) Retirement Age, No Reform



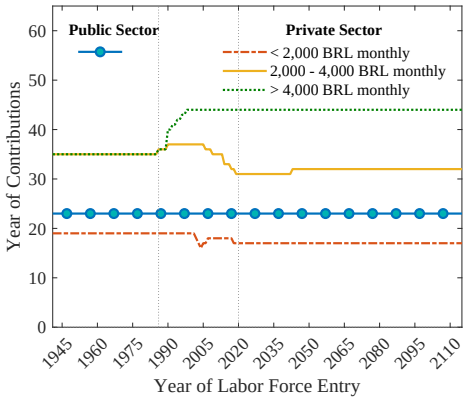
(b) Retirement Age, Increase Age Only



(c) Years of Contributions, No Reform



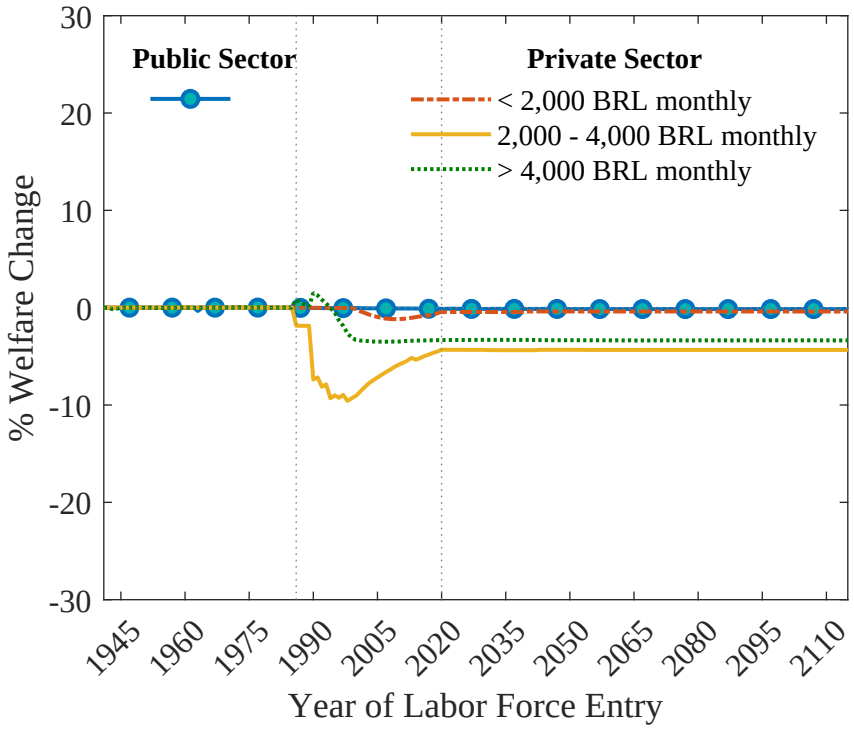
(d) Years of Contributions, Increase Age Only



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Welfare Figure 5 and 6 shows the welfare impact of the reform which increases only the statutory retirement age. This overall welfare impact showin in Figure 5 looks nearly identical to that of the

Figure 5: Welfare by Cohort: Increase Only Statutory Retirement Age



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

baseline reform, confirming the understanding that the majority of the welfare impact of reforming the system is through the changes in the retirement age.

This is also confirmed when studying the decomposition of these welfare impacts into the portions from consumption and leisure (shown in Figure 6). As in the baseline reform, the majority of welfare losses both in the transition and the short-run are driven by the decreased leisure caused by the reform. There are welfare gains from consumption in the short-run as the additional years in the labor force leads to additional years of contributions and a larger pension even without changes to the formula.[3]

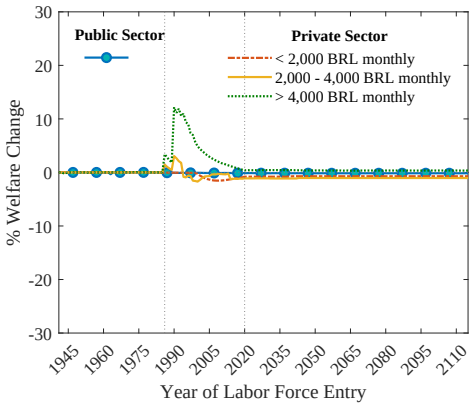
Aggregates Figure 7 shows how the aggregates evolve throughout the demographic transition path. For most variables, the evolution of these aggregates is very similar to the evolution of variables in the case of the reform. However, there are a few differences.

Most notably, when we study a reform when the statutory retirement age increases without a change in the pension formula, the capital stock remains roughly constant throughout the transition path (as shown in 7e. This is mainly due to the savings behavior of highest-income individuals. Increasing the retirement age without changing the pension formula leads the highest income individuals to receive higher pensions than they would have if the formula also changed. Due to this higher pension, these household decrease their savings over their life-cycle.

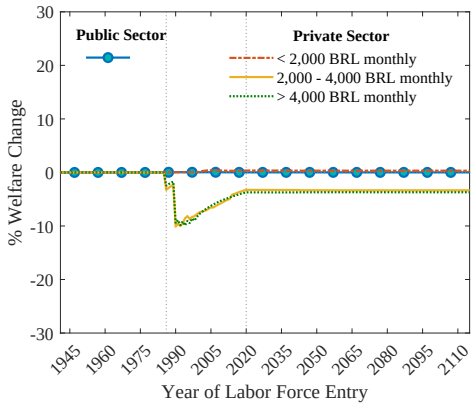
[3]This is because years of contributions are a term in the Fator Previdenciário.

Figure 6: Decomposing Welfare by Cohort: Increase Only Statutory Retirement Age

(a) Consumption



(b) Leisure



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

This higher pension has an additional impact on the labor supply as shown in Figures 7c and 7d. Because workers, especially the highest income workers, can receive higher pensions in this when the formula does not change, labor supply (both formal and informal) is higher under this reform than the baseline.

Finally, the aggregate impact on output and productivity (Figures 7a and 7e, respectively) reflects these differences in capital stock and labor supply. Relative to the baseline, increasing the statutory retirement age one induces a lower capital stock and higher labor. Reflecting these movement, output in this reform is slightly lower than the baseline (but higher than the case of no reform). Due to the lower output and higher labor than the baseline, productivity in this case is lower.

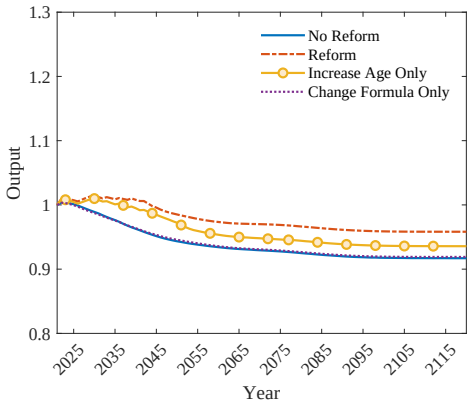
J.2 Changing Only the Pension Formula Only

As mentioned previously, the reform changes the pension formula in addition to increasing the statutory retirement age in the economy. In this section, I consider the case of a reform in which the pension formula changes as in the 2019 reform but the statutory retirement age remains fixed. This means that the path to retirement through years of contributions stays open. Recall that the changes lead to a pension forula which is more strongly increasing in the years of contributions made to the system.

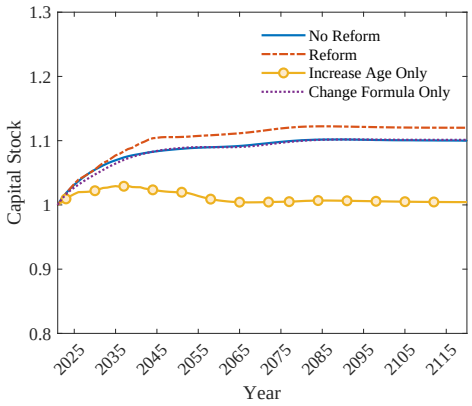
Labor Supply Figure 8 shows how the labor supply variables–retirement age and years of contributions–react to the policy change in which the pension formula is changed while the retirement age remains the same. These graphs demonstrate that these variables do not react much to this reform and that the changes in the retirement age and years of contribution react, rather, to changes in the statutory retirement age. Because the path to benefits through contributions is open, middle- and high-income workers continue accumulate 35 years of contributions and retire age 56. Low-income households and public sector workers continue to retire at age 60 and 65, respectively.

Figure 7: Aggregates: Decomposing Reform Mechanisms

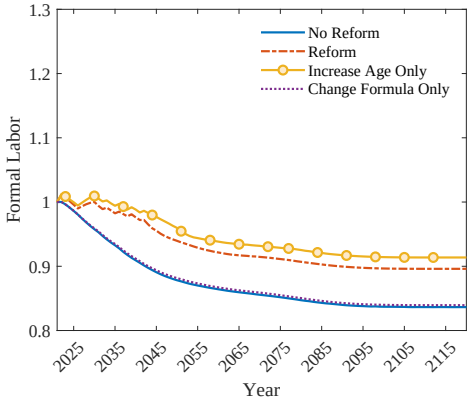
(a) Output



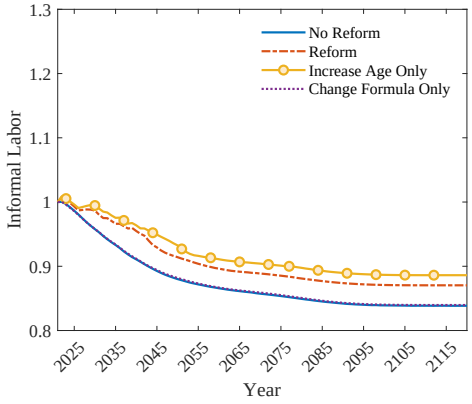
(b) Capital Stock



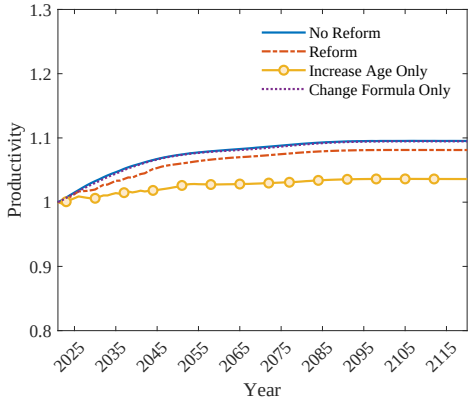
(c) Formal Labor



(d) Informal Labor



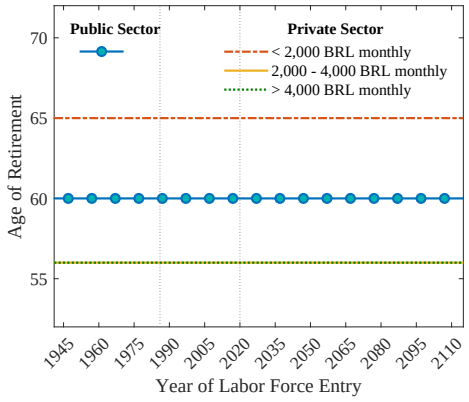
(e) Productivity



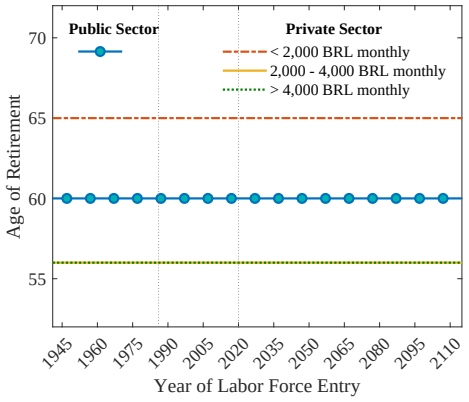
Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.

Figure 8: Retirement Age and Years of Contributions by Cohort: Change Pension Formula Only

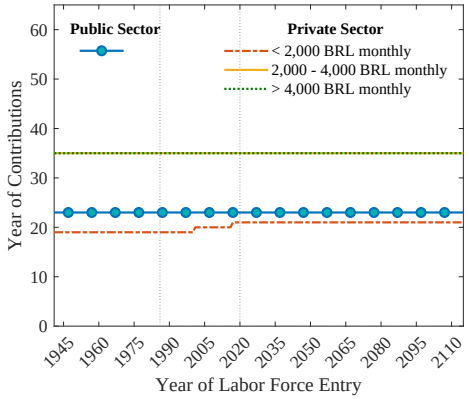
(a) Retirement Age, No Reform



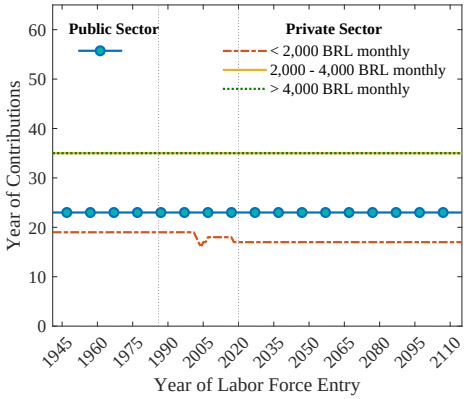
(b) Retirement Age, Change Formula Only



(c) Years of Contributions, No Reform



(d) Years of Contributions, Change Formula Only

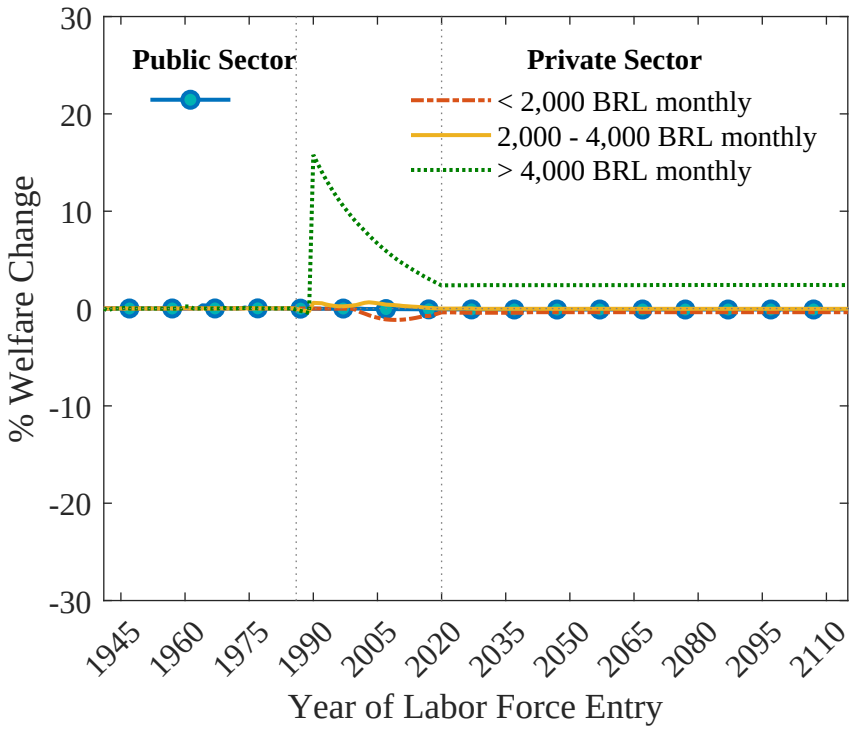


Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Welfare Figure 9 shows the overall welfare impact of the reform. This result shows that there is roughly 0 percent welfare impact for all households except the highest-income private sector workers. Any small variation in welfare for these groups are through general equilibrium impacts.

Welfare for the highest-income households, however, spikes for transitional generation and remains positive even for future generations. Figure 10 reveals that when these impacts are decomposed into the welfare gains from consumption and leisure all of the overall impact is driven by consumption variation. The welfare gains through changes in consumption, shown in Figure 10a, appears very similar to the overall welfare graph while the welfare impact from leisure in Figure 10b shows gains from leisure are 0. In this experiment, the retirement age does not change. Therefore, the reform does not lead to notable changes in leisure. The reform does lead to higher pension payments for high-income workers, both through the transition and in the long-run. These higher pension payments drive welfare gains (due to consumption changes and overall) for the highest-income workers.

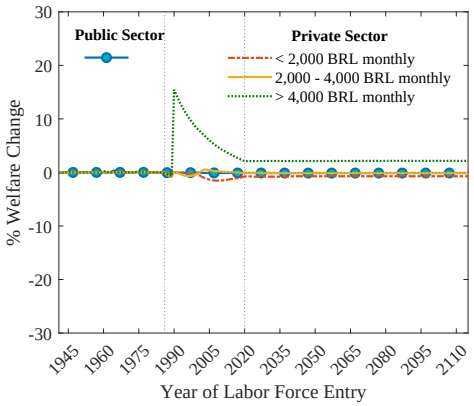
Figure 9: Welfare by Cohort: Change Pension Formula Only



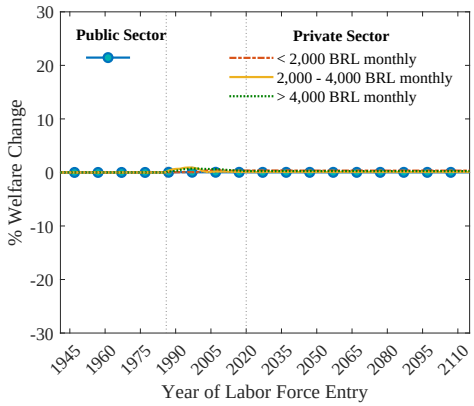
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Figure 10: Decomposing Welfare by Cohort: Change Pension Formula Only

(a) Consumption



(b) Leisure



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Aggreates Figure 7 also shows the evolution of aggreates in the case of a reform which changes the pension formula but leaves the the statutory retirement age unchanged. The aggregates in this case are nearly identical to the case of no reform. This further reinforces that the results are mainly driven by the increase in the statutory retirement age rather than this formula change.

K More on the Counterfactual Reform

This section contains additional results related to the policy counterfactual performed in Section 7 of the main text.

Labor Supply Figure 11 shows the impact of the counterfactual reform on the extensive and intensive margins of labor supply. Figures 11a and 11c show the retirement age and years of contributions in a transition path in which no reform occurs while 11b and 11d show how these same variables evolve in the case of the counter-factual reform.

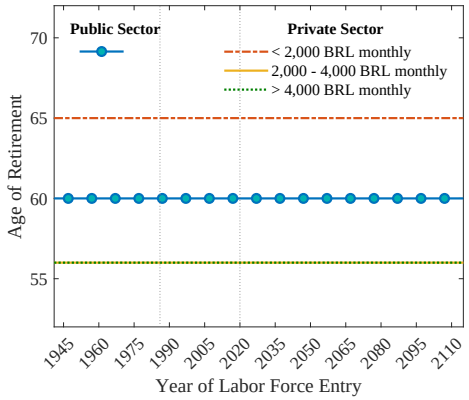
Note that the evolution of these variables is very similar to that of the baseline. This implies that changing the age at which average taxable earnings stop accumulating does not strongly impact the labor supply choices of households.

Welfare The welfare impact of the counterfactual reform is shown in Figure 12. This graph shows the welfare impact of the counterfactual reform compared with the transition path in which the Social Security system continues without reform.

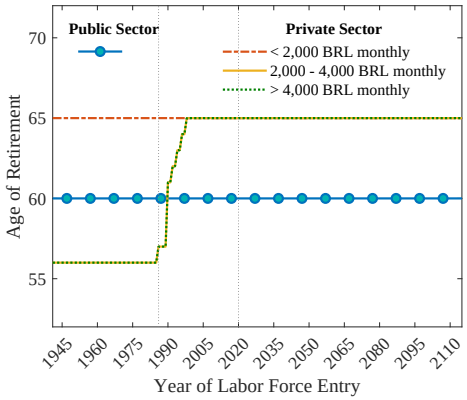
The welfare impact of this counterfactual reform is nearly the same as the welfare impact from the passed reform. These similarities are largly due to the fact that, as shown in Figure 4, most of the welfare impact of the reform is driven by the decreased leisure associated with an increase in the retirement age. Since this remains constant in this experiment, the patterns of welfare impacts from reforming the system are very similar.

Figure 11: Retirement Age and Years of Contributions by Cohort: Counterfactual Reform

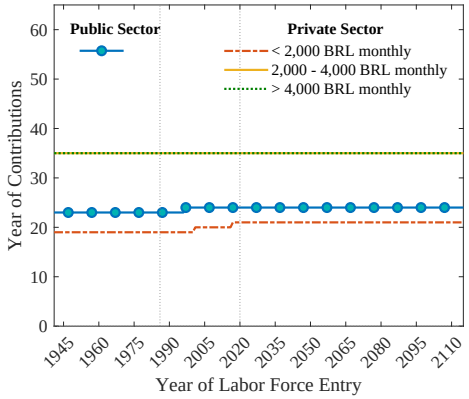
(a) Retirement Age, No Reform



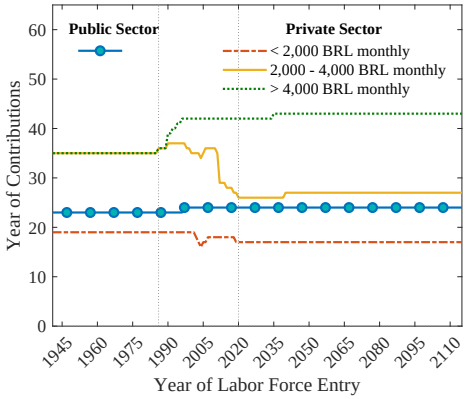
(b) Retirement Age, Reform Counterfactual



(c) Years of Contributions, No Reform



(d) Years of Contributions, Reform Counterfactual

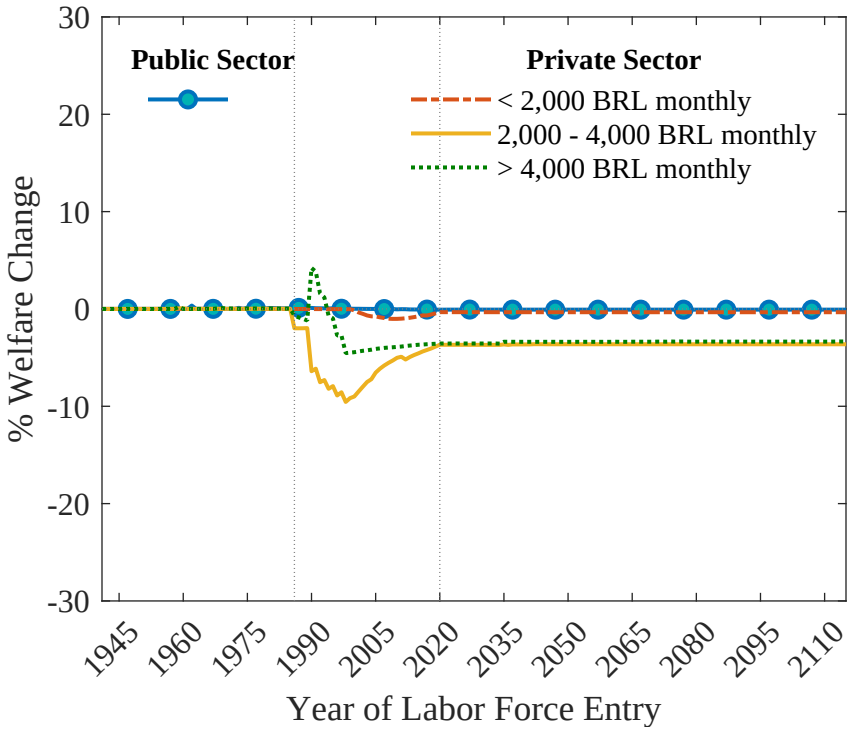


Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Despite the similarities, long-run welfare losses for high-income individuals are slightly lower in this experiment than in the passed reform. Because the life-cycle productivity features a hump shape, stopping accumulations of average taxable earnings at age 55 leads to higher average taxable earnings and higher pensions for these households. These higher pensions lead high-income private sector workers to receive higher consumption in retirement and decrease their welfare losses relative to the benchmark case of the passed reform.

Aggregates The evolution of the aggregates in the transition path associated with the counterfactual reform are shown in Figure 13. This result shows that the aggregates in this reform are very similar to those in the case of the baseline reform. This result demostrates that indexing pension benefits to age 55 does not strongly impact the behavior of economic individuals or the macroeconomic aggregates.

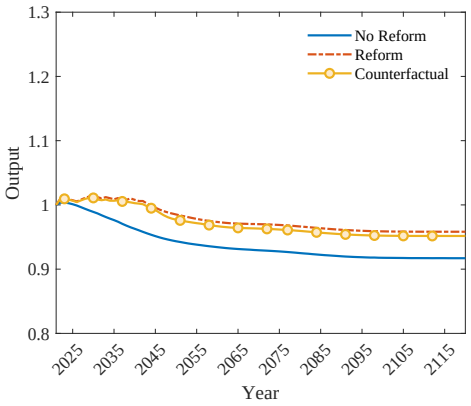
Figure 12: Welfare by Cohort: Continue Current Policy vs. Counterfactual Reform



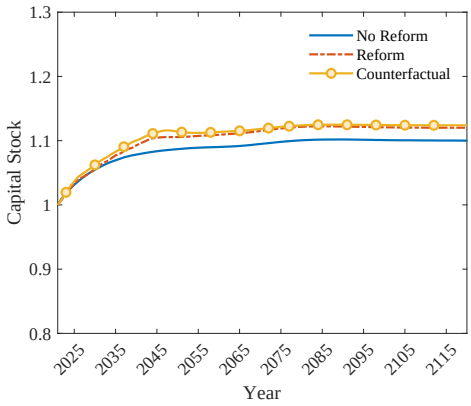
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Figure 13: Aggregates: Counterfactual Reform

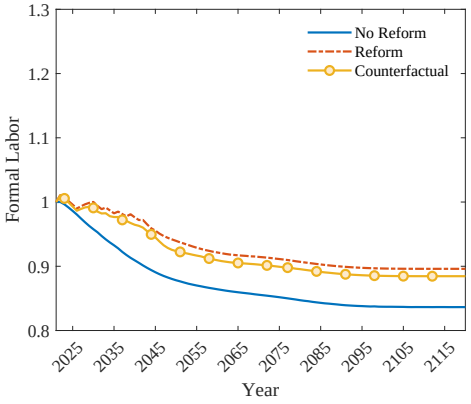
(a) Output



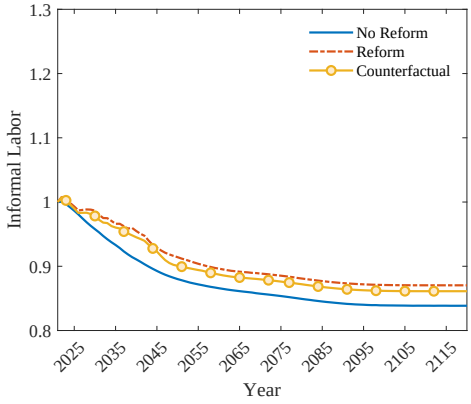
(b) Capital Stock



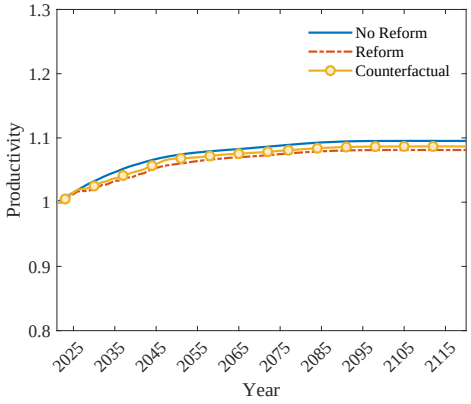
(c) Formal Labor



(d) Informal Labor



(e) Productivity



Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.

Table 13: Long-Run Relative Pension Sizes: Public Sector Reforms, τ_{ss} Constant

	No Reform	Public Sector Reforms	Contribution Rate Constant
Public Sector	1.000	1.289	1.003
Private Sector			
2,000 BRL	1.000	1.000	1.000
2,000-4,000 BRL	1.000	1.000	1.000
4,000 BRL	1.000	1.501	1.494

Notes: All reform experiments are shown relative to the case of the baseline no reform.

L Sensitivity

In this section, I present the results of the transition path under various changes.

L.1 Pubilc Sector Reforms Too

The Brazilian reform only changed the pension system for private sector workers while keeping the, very generous, system for public sector workers that same. In this section I consider a reform in which the pension program for public sector workers also changes. I assume that public sector workers must take on the contribution rates of the private sector workers and receive benefits according the same eligibility requirements and benefit formula.

In order to impute the contribution rates that would be paid by public sector workers, I use the PNAD data to construct the average family contribution rate in which all workers rates are constructed according to the tax schedule for private sector workers after the reform. Table 14 shows the tax rates used.

Labor Supply Including public sector employees in the reform has important implications for the impact of the reform on labor supply of these public sector employees. The change in the retirement age and years of contributions are shown in Figure 14. For private sector households, the impact of this reform is the same as the baseline. For private sector employees, this reform increases the public sector retirement age from 60 to 65. Additionally, the reform increases the contributions of public sector employees from 21 years to 44 years. After the reform, public sector employees are incentivized to increase their contributions and, thus, their pensions. These workers increase their labor force participation–specifically their formal sector labor force participation–in order gain the higher pension.

Welfare Figure 15 shows the overall welfare impact of this reform; Figure 16 shows the welfare impact decomposed into the portion from consumption and the portion from leisure.

The overall welfare impact, as well as the decomposed result, are very similar to the baseline for private sector workers. The welfare impact for public sector workers is very different. Welfare

Table 14: Household Tax Rates: Public Sector Reforms

	Income Tax Rate (τ_h)	Contribution Rate (τ_{ss})	
		Before Reform	After Reform
Public Sector	5.11%	13.43%	29.30 %
Private Sector	3.07%	28.08%	29.24%
$\leq 2,000$ BRL	0.00%	28.02%	28.27%
$2,000 - 4,000$ BRL	1.45%	28.37%	29.47%
$> 4,000$ BRL	10.35%	27.59%	30.06%

Notes: Employers of private sector workers also contribute 20 percent of payroll which is assumed to be passed on to the household.

losses for future generations are roughly 10 percent of lifetime consumption. These losses begin with transitional generations and become larger throughout the transition. Generations who were already retired at the time of the reform experience nearly no impact of the reform on welfare.

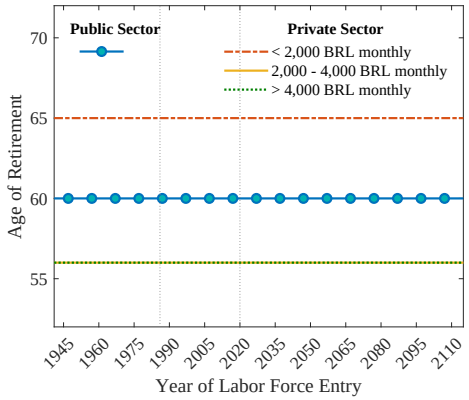
The decomposition of this reform in Figures 16a and 16b demonstrated that this overall welfare is mainly driven by consumption variation but there are some welfare losses from movements in leisure. While public sector workers do experience decreased leisure from the increase in the retirement age, this increase was much smaller than that of private sector workers. Therefore, while roughly 20 percent of these losses can be attributed to leisure, this share is smaller than for private sector workers. Rather, welfare losses from consumption play a much larger role. This is driven by the large increase in the contribution rate these workers face.

Aggregates Figure 17 shows how output, capital stock, labor supply, and productivity evolve throughout the transition paths. These aggregates are very different in the case of a reform in which the public sector also reforms than in the baseline reform. First, when the public sector also reform capital stock is not only lower but also drops throughout the transition (shown in Figure 17b). In this reform, public sector workers–who are high income workers–move into a system in which they pay higher contribution rates but also receive higher pensions. These higher pensions promised lead these public sector workers to decrease their savings. Second, the higher contribution rate changes the composition of formal and informal labor supply. Relative to the baseline, Figures 17c and 17d show that in this reform formal sector labor supply is higher while informal sector labor supply is lower.[4] The drop in overall labor supply (despite the composition changes) along with the drop in the capital stock lead to lower output in this reform (shown in Figure 17a). Finally, Figure 17e shows that the evolution of productivity is similar to that of the

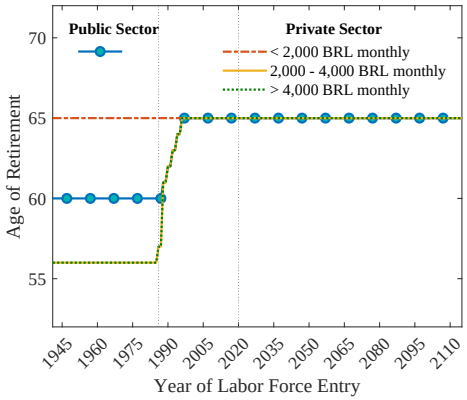
[4]This movement in formal and informal labor in response to change in the contribution rate is discussed in McKiernan (2021). In short, a higher contribution rate increases the ratio of formal to informal hours as workers have to work more formally to earn the same after-tax income.

Figure 14: Retirement Age and Years of Contributions by Cohort: Public Sector Reforms Too

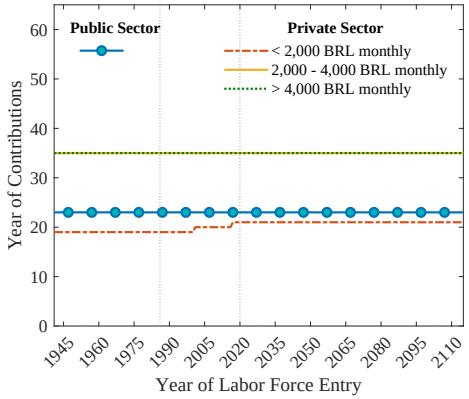
(a) Retirement Age, No Reform



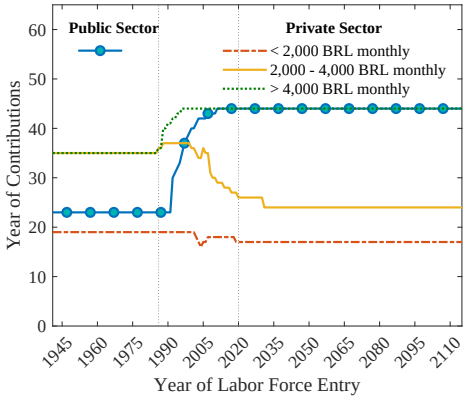
(b) Retirement Age



(c) Years of Contributions, No Reform



(d) Years of Contributions



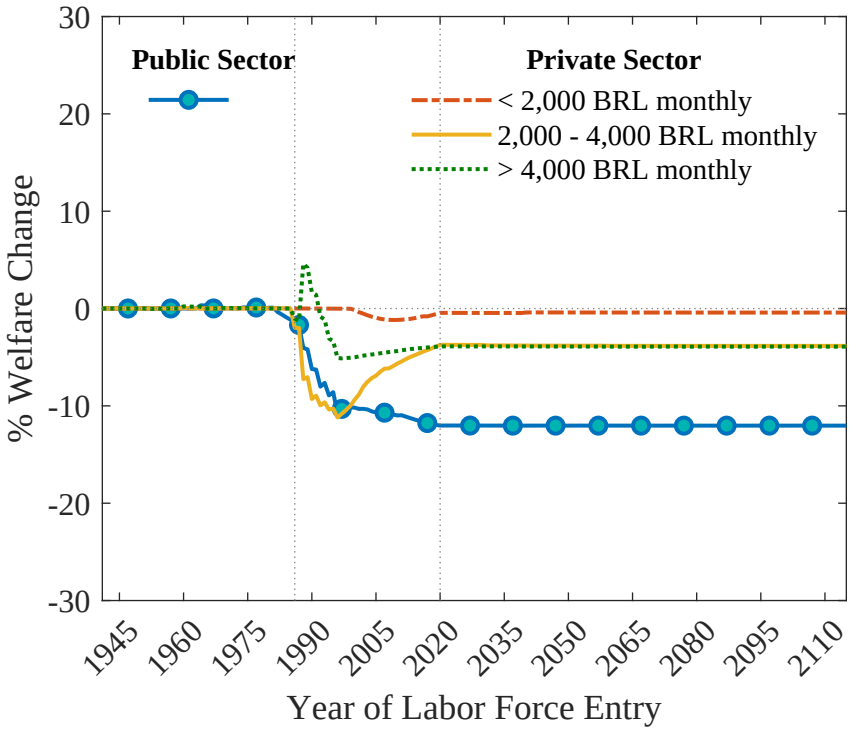
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

baseline. However, despite the lower output, higher labor supply in this reform (relative to the baseline) leads to slightly lower productivity in the reform in which the public sector also reforms.

L.2 Contribution Rate Does Not Change

The 2019 Brazilian Reform also included small changes to the Social Security contribution rate schedule which made the contributions more progressive. This led to increases in the contribution rate for all the productivity level groups considered. Households in which the head of household works in the public sector experience a increase of 0.22 pp. Within the private sector, low-income households experience an increase of 0.25pp, middle-income households see their contribution rates increase 1.1pp, and high-income workers have an increase of 2.47pp. These increasese in the contribution rates cause changes in not only the total labor supply of households but also the ratio of formal to informal sector hours. These changes may impact the results of the analysis. Therefore, I consider a reform in which everything occurs as it did in the passed reform except the contribution rate remains constant.

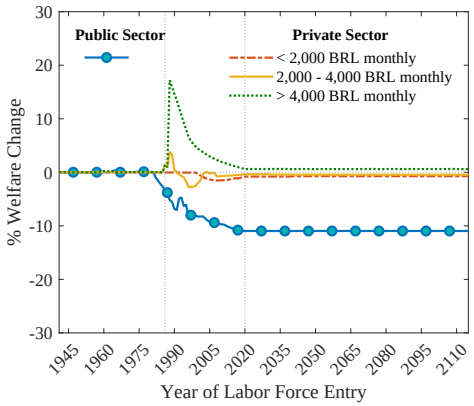
Figure 15: Welfare by Cohort: Continue Current Policy vs. Reform in which Public Sector Reforms



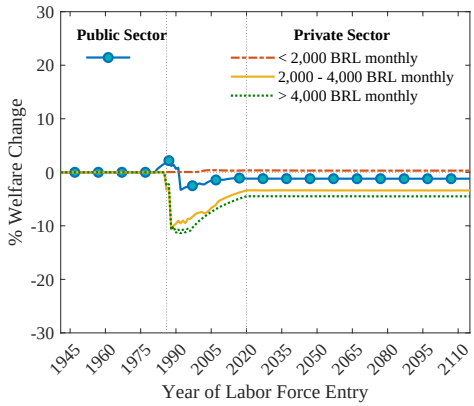
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Figure 16: Decomposing Welfare by Cohort: Public Sector Reform

(a) Consumption



(b) Leisure



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

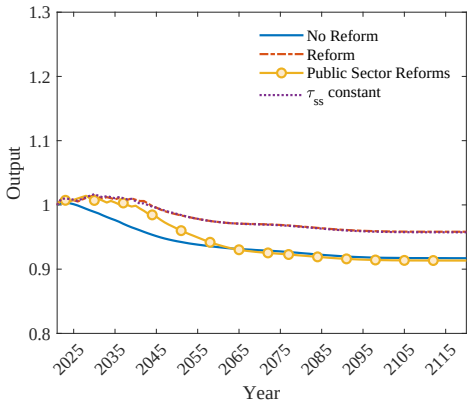
Labor Supply Changes in tax rates are important to understanding the labor supply behvior of households. Figure 19 shows the labor supply impact of the reform in which the contribution rate remains constant. Figure 19b shows how the retirement age evolves in this transition path. Because the statutory retirement rate is the same as the benchmark economy, the impact of this reform on the retirement age is identical. Figure 19d shows the years of contributions. Here there is an interesting result. While the years of contributions for the high-income workers increases to 44 throughout the transition path as in the baseline, the years of contributions for middle- and low-income workers drop to 22 year and 10 years, respectively. These are below the values of 23 years for the middle-income in the baseline and 17 years for low-income workers in the baseline. The lower contribution rate in this experiment means workers increase their informal labor supply (relative to their formal labor supply) and do not achieve as many years of formal participation. Despite these lower years of contributions, since these workers receive only the minimum pension, their pensions are unchanged.

Welfare The welfare impact of the reform with constant contribution rates is shown in Figure 20. As the figure shows, the welfare impact of the reform is very similar to that of the baseline reform. This is consistent with the fact that the majority of the welfare losses are driven by the decreases in leisure due to increased retirement age. One notable difference how the long-run welfare losses differ between middle- and high-income households. In the baseline, these workers had the same welfare losses. In the experiment with constant contribution rates, the high-income workers experiend smaller long-run welfare losses than middle-income households.

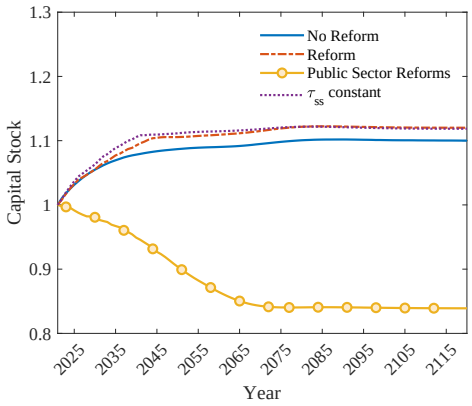
This difference is also seen in the decomposition of welfare shown in Figure 20. While the leisure contribution to the welfare losses is very similar to the case of the baseline. The welfare impact of consumption changes shows long-run welfare gains for high-income households. These gains are due to the smaller contribution rates in this example. Since high-income workers experience the largest increase in contribution rates from the reform, they also have the largest decrease in this example. The consumption impact for other productivity levels is much smaller (roughly 0)

Figure 17: Aggregates: Public Sector Reforms, τ_{ss} Constant

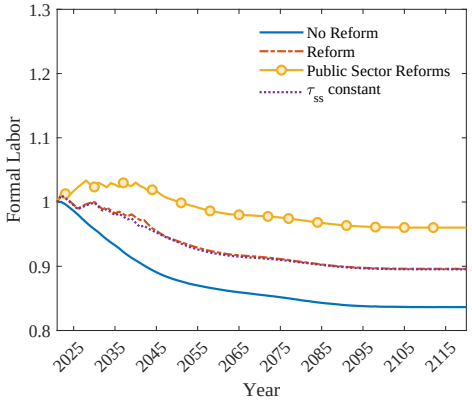
(a) Output



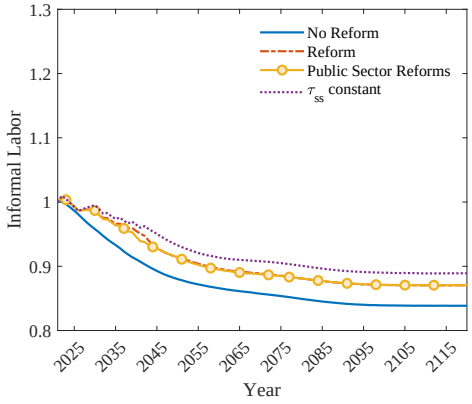
(b) Capital Stock



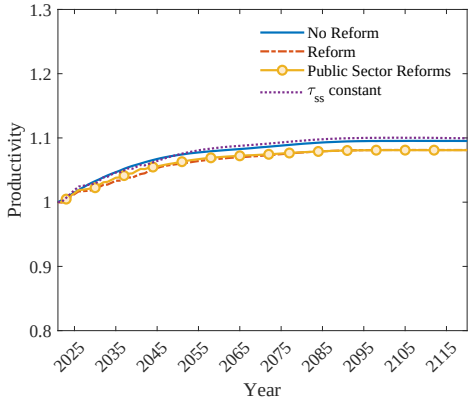
(c) Formal Labor



(d) Informal Labor

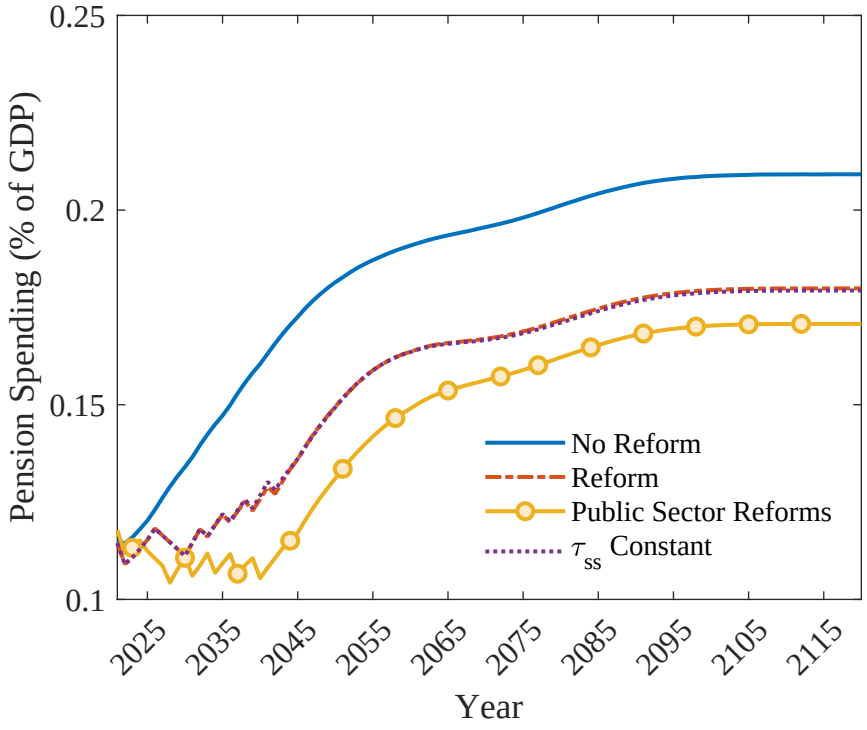


(e) Productivity



Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.

Figure 18: Aggregate Pension Spending: Public Sector Reforms, τ_{ss} Constant



as the reform as passed in 2019, did not largely increase their contribution rates.

Aggregates Figure 17 also shows the evolution of the aggregates in the case of a reform which is the same as the baseline but does not allow the contribution rate to change. In this case, the aggregates are nearly identical to the baseline. The changes in the contribution rate associated with the reform are not large enough to drive large differences in many aggregates. The one exception is that informal labor supply is slightly higher in the reform in which τ_{ss} does not change. The baseline reform increased contribution rates for all private sector workers. Therefore, without these increases, workers do not substitute to the formal sector.[5]

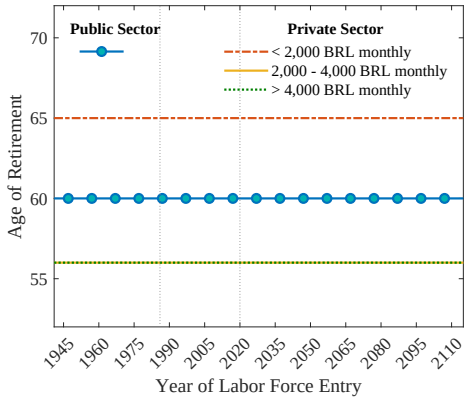
L.3 Productivity

The baseline results include the assumption that not only does productivity grow over the life-cycle and feature a hump-shape but also that this growth is constant across the various fixed productivity types. In this section, I relax these assumptions in two way. First, I assume productivity is fixed across the life-cycle. Second, I assume that productivity does feature growth and this growth varies by fixed productivity type.

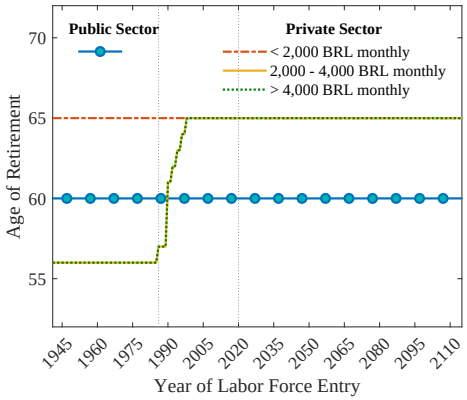
[5]Note that formal labor is also lower in this reform than in the baseline. However, since formal labor is higher in levels, the percentage change is smaller and more difficult to see in the graph

Figure 19: Retirement Age and Years of Contributions by Cohort: Contribution Rate Constant

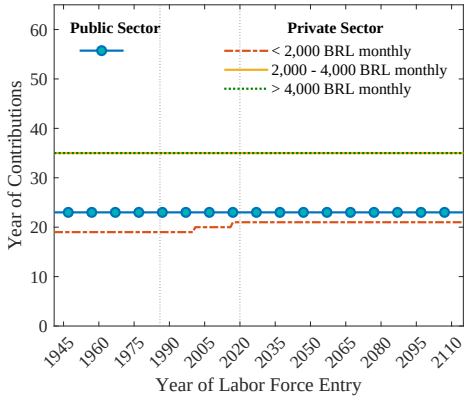
(a) Retirement Age, No Reform



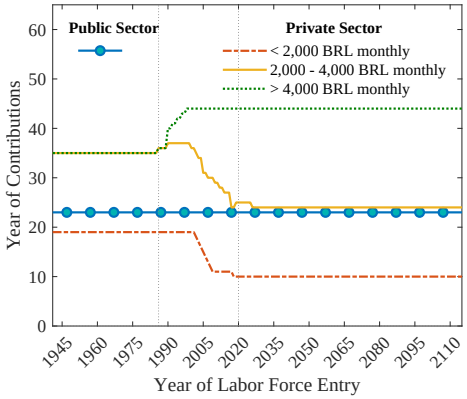
(b) Retirement Age



(c) Years of Contributions, No Reform



(d) Years of Contributions



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Recall that productivity of an age j household in the model is defined as:

$$\varepsilon_j = \overline{\varepsilon}\,(1 + g_j) \tag{17}$$

where $\overline{\varepsilon}$ is a fixed productivity level and g_j defines growth over the life-cycle. This section will detail changes to this function.

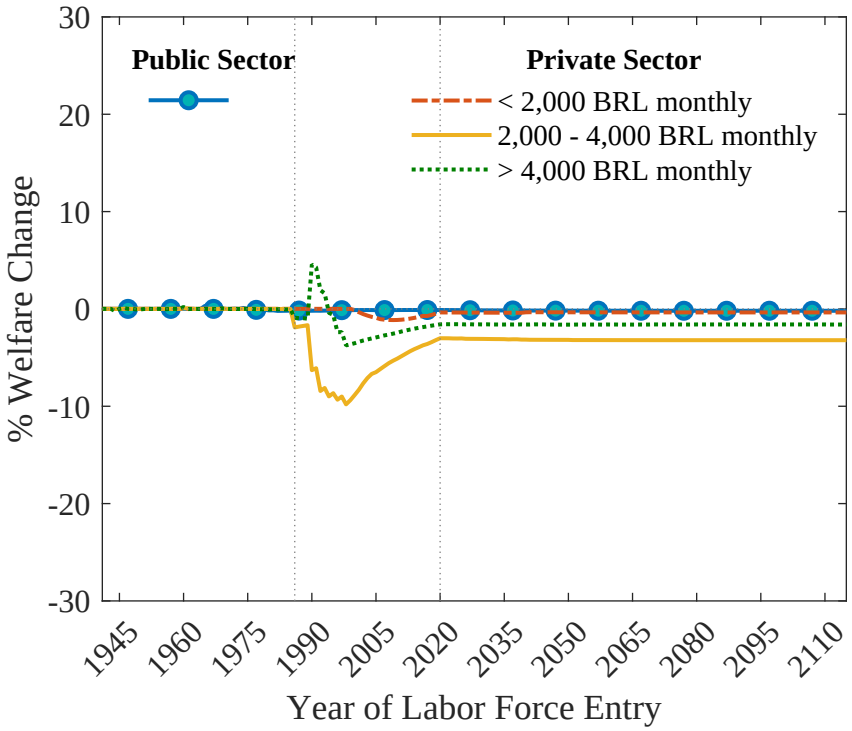
L.3.1 Flat Across Life-cycle

First, I consider a case in which productivity is flat over the life-cycle. Relative, to Equation 17 this means that productivity is defined as:

$$\varepsilon_j = \overline{\varepsilon} \tag{18}$$

Or, the productivity of a household at any age j is determined based only on its fixed productivity level.

Figure 20: Welfare by Cohort: Contribution Rate Constant



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

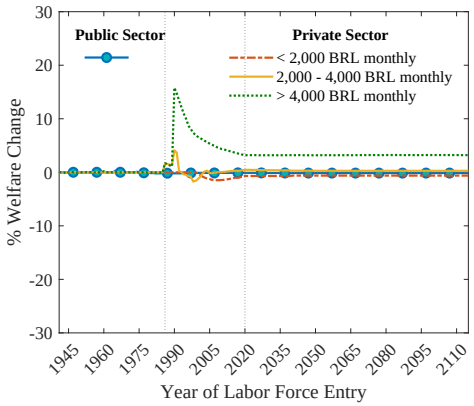
Table 15: Long-Run Relative Pension Sizes: Productivity and Informality Experiments

	No Reform	Productivity Flat	Productivity by Income	Same Sectoral Shares	Formality Only
Public Sector	1.000	1.002	1.000	1.001	1.011
Private Sector					
2,000 BRL	1.000	1.000	1.000	1.000	1.000
2,000-4,000 BRL	1.000	1.000	1.000	1.000	1.059
4,000 BRL	1.000	1.485	1.529	1.511	1.274

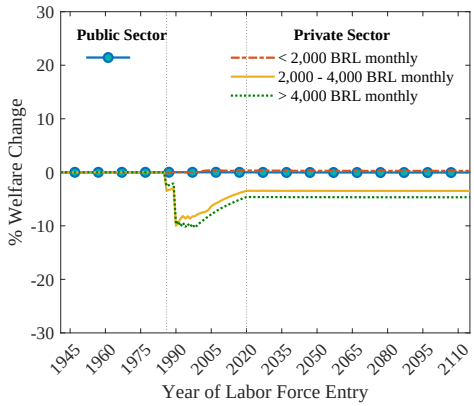
Notes: All reform experiments are shown relative to the case of no reform within the experiment (i.e. Formality Only shows the pension size that results from the reform in an economy with no informality relative to the pension size that results from no reform in the economy without informality).

Figure 21: Decomposing Welfare by Cohort: Contribution Rate Constant

(a) Consumption



(b) Leisure



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Labor Supply Labor supply variables across birth-year cohorts are shown in Figure 22 where Figures 22a and 22c show the evolution of retirement age and years of contributions in the case of no reform while Figures 22b and 22d show the same variables in the case where a reform occurs.

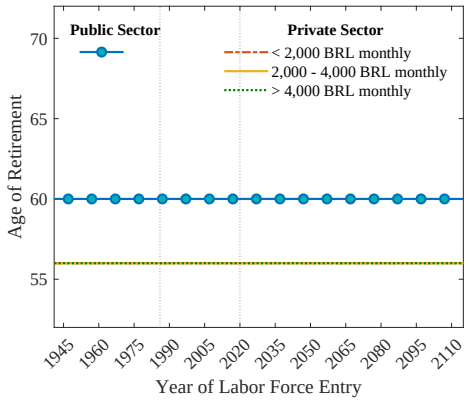
The first notable this to mention is that in the case of flat productivity all private sector workers achieve the necessary 35 years of contributions and retire at age 56 prior to the reform. This means that the reform leads to gradual increase in the retirement age for all private sector workers rather than only middle- and high-income private sector workers. Additionally, because low-income private sector workers move from needing 35 years of contributions to needing only 20 years of contributions after the reform, there is also a large drop in years of contributions for this group. In contrast, middle-income private sector workers hold their years of contributions relatively constant which high-income private sector workers increase their years of contributions in order to receive a larger pension.

Welfare Welfare impact of the reform in an economy with flat productivity is shown in Figure 23. The welfare impact of the reform on public sector, middle-income private sector, and high-income private sector workers is very similar to the baseline. The difference comes for low-income private sector workers. These workers experience welfare losses of around 20 percent of remaining lifetime consumption in the transition and welfare losses of around 5 percent of consumption in the long-run. The decomposition of these losses into the portion from consumption changes and the portion from leisure changes are shown in Figure 24.

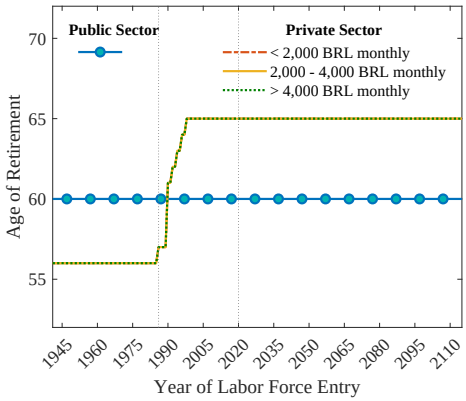
Figure 24a shows the majority of welfare losses for low-income transitional generations that come from consumption changes. This is very different from the baseline in which welfare losses were mainly driven by leisure changes. In this experiment, the reform leads low-income private sector workers to increase their retirement age but does not compensate them with a higher pension since they continue to receive only the minimum. Therefore, since these transitional generations do not have savings to compensate themselves for not receiving the pension income for additional years, they experience large transitional welfare losses from consumption changes.

Figure 22: Retirement Age and Years of Contributions by Cohort: Productivity Flat Over the Life-Cycle

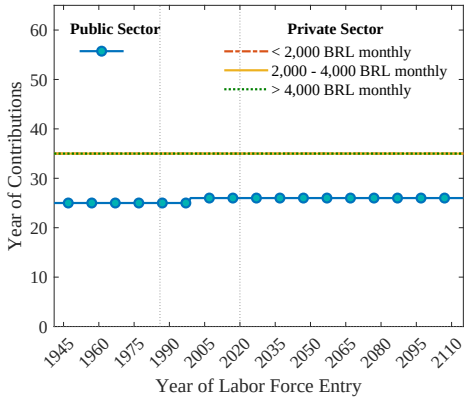
(a) Retirement Age, No Reform



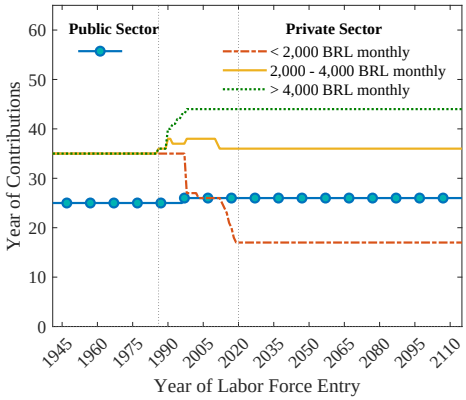
(b) Retirement Age, Reform



(c) Years of Contributions, No Reform



(d) Years of Contributions, Reform



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

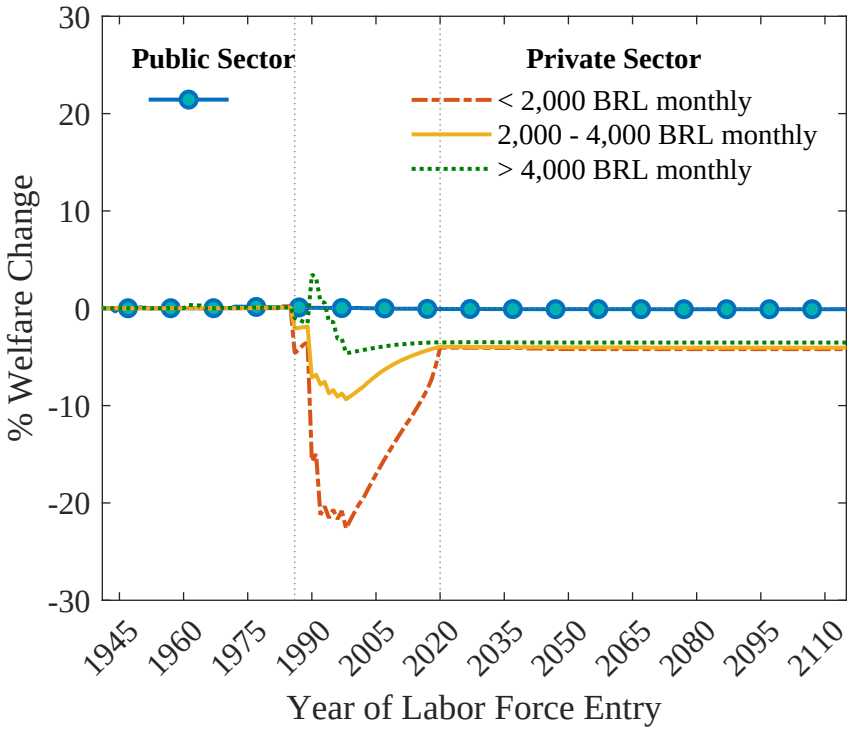
Figure 24b demonstrates that while most transitional welfare losses for these low income workers is due to consumption changes, there is some due to leisure changes. Since low-income workers are forced to increase their working years in this experiment, they also experience transitional welfare losses from lost leisure. In the long-run, these workers also experience welfare losses from leisure associated with short retirement.

This is logic that I see in other experiments. The driving force in many welfare changes is dependent on the pattern of retirement decisions across fixed productivity types that appeared before the reform.

Aggregates Time series for aggregates (relative to before the transition path begins) are shown in 25. Qualitatively, these aggregate series appear very similar to the baseline reform.

Differences that occur are due mainly to the differences in how capital stock evolves in the case of no reform (Figure 25b). In the baseline, capital stock increases throughout the transition path whether the reform occurs or not. In this experiment in which productivity is flat, long-run

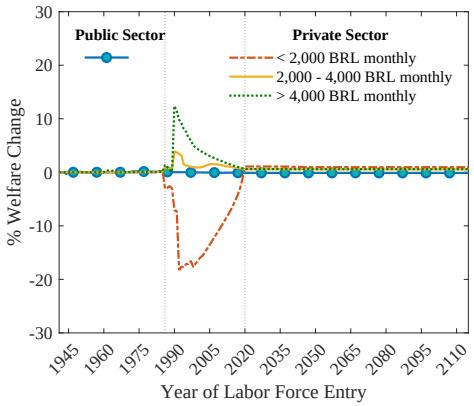
Figure 23: Welfare by Cohort: Productivity Flat Over the Life-Cycle



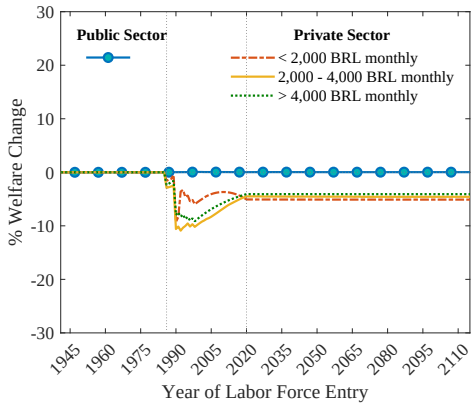
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Figure 24: Decomposing Welfare by Cohort: Productivity Flat Over the Life-Cycle

(a) Consumption



(b) Leisure



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

capital is roughly the same as prior to the reform. Therefore, there is a larger gap between the capital stock in the case of no reform and the case of a reform in this experiment then translates in a larger gap between output levels in the two cases (Figure 25a). While output is higher in the case of reform in the baseline, the gap between output in the case of no reform and reform is larger in this experiment. This higher output level in the experiment of flat productivity then translate into higher aggregate productivity (Figure 25e). Contrary to the baseline, when I assume flat life-cycle productivity, aggregate productivity (output per efficient unit of labor) is higher when the reform occurs.

In addition to the aggregate levels of output, capital stock, labor supply, and productivity. Figure 26a shows the impact of the reform on aggregate pension spending. As in the baseline, the reform decreases aggregate pension spending. In this experiment, however aggregate spending drops 4-5 percentage points of GDP rather than the 3 percentage points of GDP in the baseline. This difference is due to higher pension spending in the case of no reform in this experiment. Because the low-income workers also retire young in this experiment pension spending is higher prior to reform. Therefore, the drop from the reform is larger.

L.3.2 Varies by Income Group

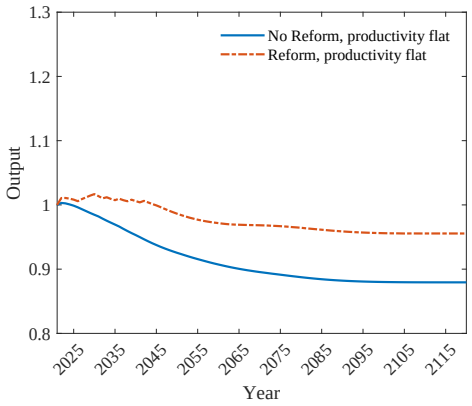
Second, I consider a case in which productivity features growth over the life-cycle which varies by fixed type. Relative, to Equation 17 this means that productivity is defined as:

$$\varepsilon_j = \overline{\varepsilon}\left(1 + g_j\left(\overline{\varepsilon}\right)\right) \tag{19}$$

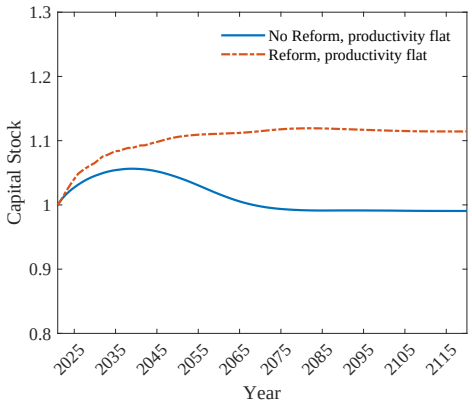
Or, the productivity of a household at any age j is determined based not only on its fixed productivity level but some growth $g_j\left(\overline{\varepsilon}\right)$ which is a function of the fixed productivity level. The life-cycle profiles used in this experiment are show in Figure 1b.

Figure 25: Aggregates: Productivity Flat Over the Life-Cycle

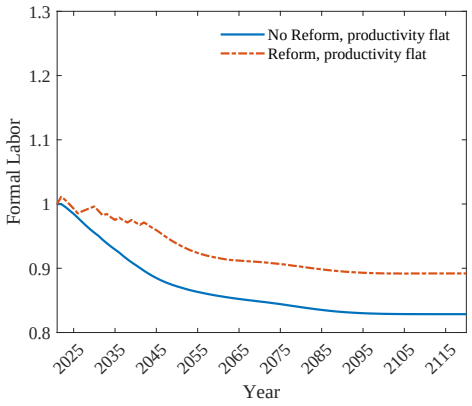
(a) Output



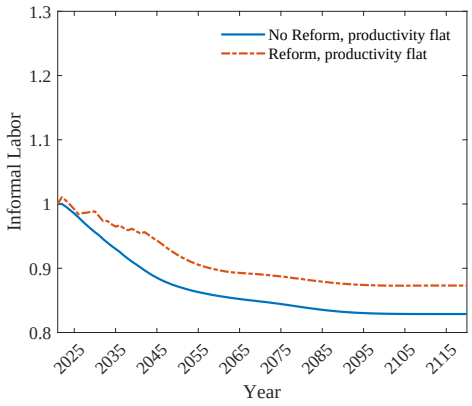
(b) Capital Stock



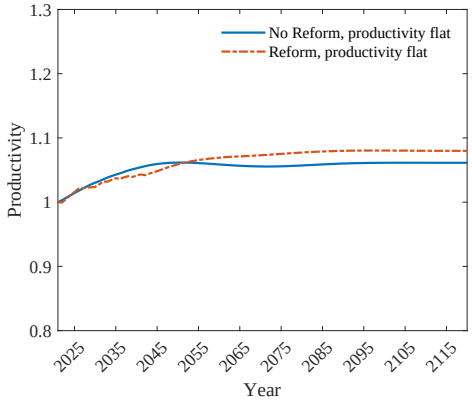
(c) Formal Labor



(d) Informal Labor



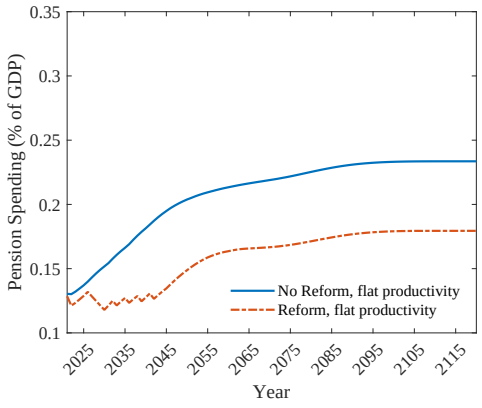
(e) Productivity



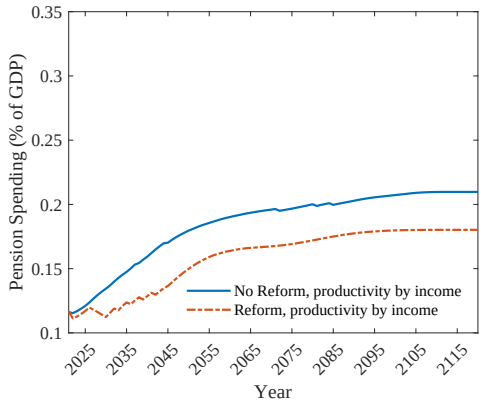
Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.

Figure 26: Aggregate Pension Spending: Productivity Experiments

(a) Productivity Flat Over the Life-Cycle



(b) Productivity by Income



Labor Supply Figure 27 shows labor supply variables with and without reform for the economy with productivity growth which varies by fixed type and across the life-cycle. Differently than when productivity is flat, this experiment once again features the same heterogeneity in retirement behavior across income levels of private sector workers that appeared in the baseline; middle- and high-income workers accumulate 35 years of contributions and retire at age 56 while low-income workers do not accumulate sufficient years of contributions and retire at age 65. Due to this, the evolution of years of contributions also looks similar to the baseline (rather than the experiment with flat productivity). Low-income private sector worker hold their years of contributions relatively constant. Rather, middle-income private sector workers drop their contributions from 35 years to 20 years while high-income private sector workers increase their contributions to 44 years.

Welfare Because the patterns of retirement decisions and years of contributions in this experiment are similar to those of the baseline reform, the welfare impact (Figure 28) also appears similar. Specifically, there is very little change in the welfare for public sector and low-income private sector households while middle- and high-income private sector workers experience welfare losses both in the transition and in the long-run.

Decomposing the welfare impact into portions from consumption and leisure (Figure 29) also shows that welfare impacts of this experiment are similar to those of the baseline. Slight differences occur in the welfare impact–both through variation in consumption and through variation in leisure–for middle-income private sector workers, but these differences are quantitatively small.

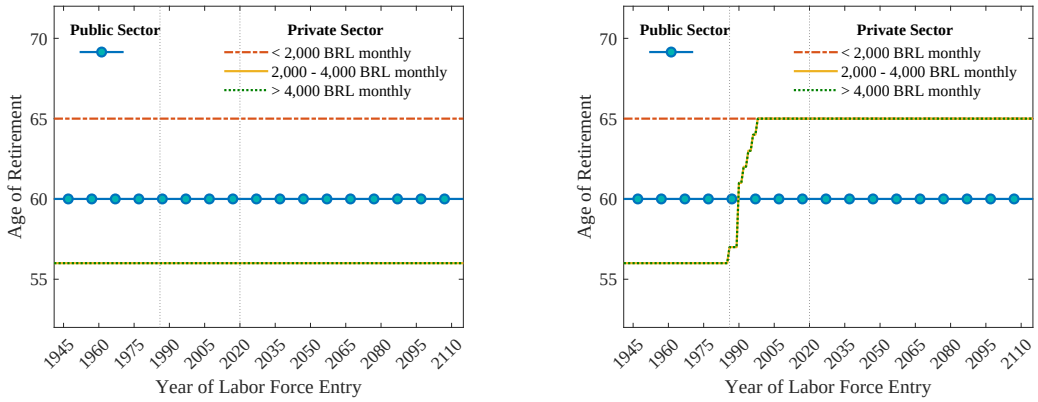
Aggregates Figure 30 presents the time series of the aggregate in an economy with life-cycle productivity growth that varies by income group. The largest difference between these time series and those for the baseline is that Figure 30b shows that capital stock is lower after the reform than if the reform had not occurred. In this experiment, both middle- and high-income workers experience higher growth that in the baseline.[6] After the reform, these same workers receive a much higher pensions and decrease their savings. The other series feature the same qualities as the

[6]However, while high-income workers see hump-shaped growth over the life-cycle, growth for middle-income workers is roughly flat over the life-cycle.

Figure 27: Retirement Age and Years of Contributions by Cohort: Productivity Growth Varies by Income

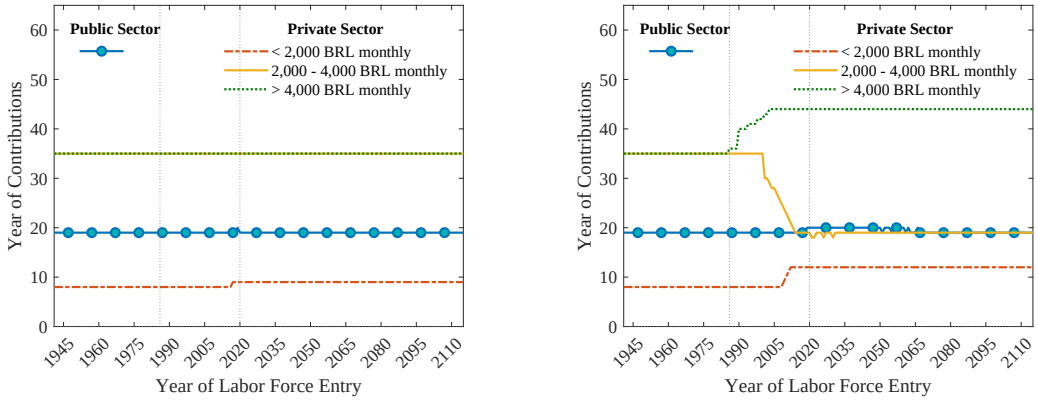
(a) Retirement Age, No Reform

(b) Retirement Age, Reform



(c) Years of Contributions, No Reform

(d) Years of Contributions, Reform



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

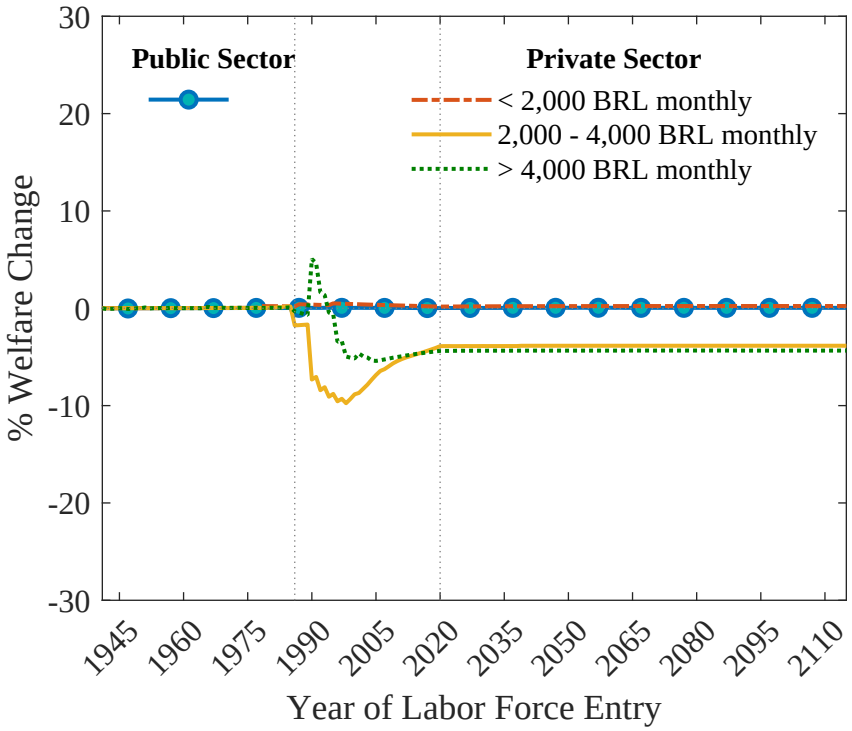
baseline results. Specifically, after the reform both formal and informal labor, as well as output and productivity are higher. The magnitudes the of the differences across the case of not reform and reform are smaller, however. While the labor supply variables feature roughly same quantitative changes as the baseline, the impact of the reform on output differs. Because the capital stock is smaller after the reform, while output post-reform is larger than pre-reform, the difference better the series is smaller. Finally, because output is lower (relative to the baseline) productivity is also lower than in the baseline.

L.4 Informality

In the baseline results, the parameters which govern formality and informality differ by fixed productivity level. The share of formal hours to informal hours is given by:

$$\Gamma_{\varepsilon}\left(h_{ft}, h_{it}\right) = \left[a_{\varepsilon} h_{ft}^{b_{\varepsilon}} + \left(1 - a_{\varepsilon}\right) h_{it}^{b_{\varepsilon}}\right]^{\frac{1}{b_{\varepsilon}}} \tag{20}$$

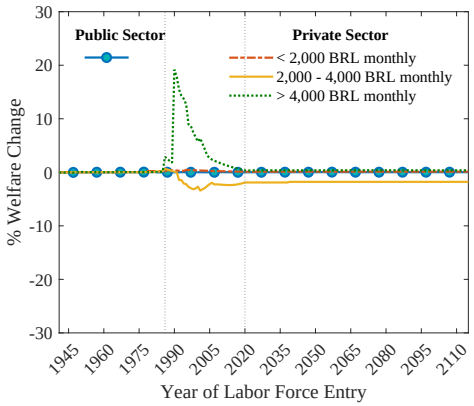
Figure 28: Welfare by Cohort: Productivity Growth Varies by Income



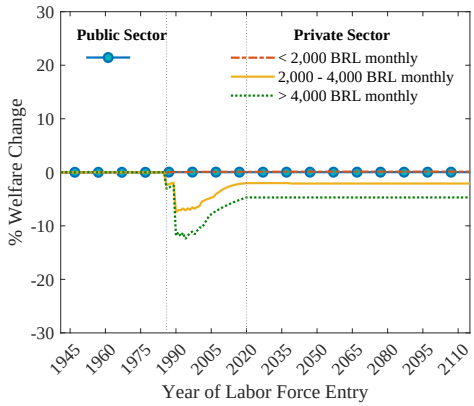
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Figure 29: Decomposing Welfare by Cohort: Productivity Growth Varies by Income

(a) Consumption



(b) Leisure



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

In this section, I change this. First, I consider the case of all types have the same parameters of the market labor supply equation. Second, I assume there is no informality in the economy.

L.4.1 Same Sectoral Shares

In this section I consider a case in which the parameters which govern formality and informality does not differ by income level. This means that Equation 20 becomes:

$$\Gamma\left(h_{ft}, h_{it}\right) = \left[a h_{ft}^{b} + (1-a)\, h_{it}^{b}\right]^{\frac{1}{b}} \tag{21}$$

Note that the difference is that the parameters a, b do not vary by fixed productivity type.[7] In this case the parameters of the function $\Gamma\left(\cdot\right)$ are those reported in the first column of Table 10.

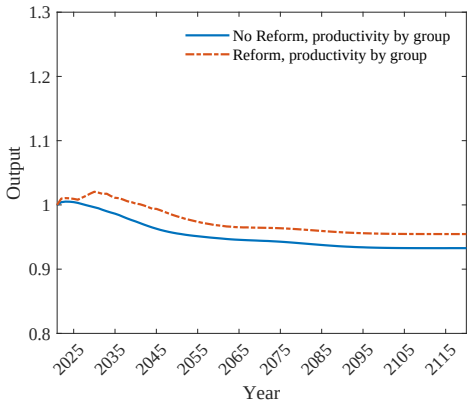
Labor Supply Figures 31a and 31c show how the retirement age and years of contributions evolve without a reform in this experimental economy in which the parameters of the market labor supply function are the same. Figures 31b and 31d shoe the retirement age and contributions throughout the transition when the reform occurs.

As with the case of flat productivity over the life-cycle, when these parameters do not differ by income level, all private sector workers retire under the contributions path if no reform occurs. No matter the income level, private sector workers accumulate 35 years of contributions and retire at age 56. This also means that when the reforms occurs, all these workers are forced to increase their retirement age throughout the transition. After the transition, once again, years of contributions diverge by income level. Low-income and middle-income private sector workers decrease their years of contributions while high-income households increase their formal participation and, thus, contributions.

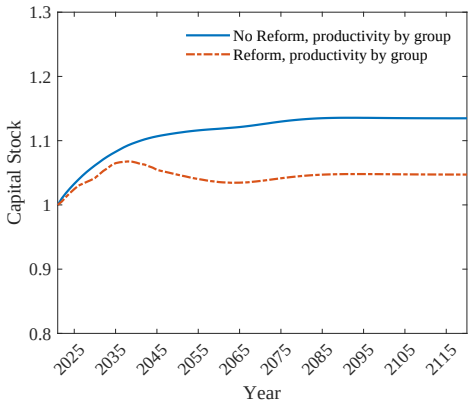
[7]This does not mean that $\frac{h_f}{h_i}$ is the same for all types. Because each income level faced a different tax rate, the shares of formality to informality will also differ

Figure 30: Aggregates: Productivity Growth Varies by Income

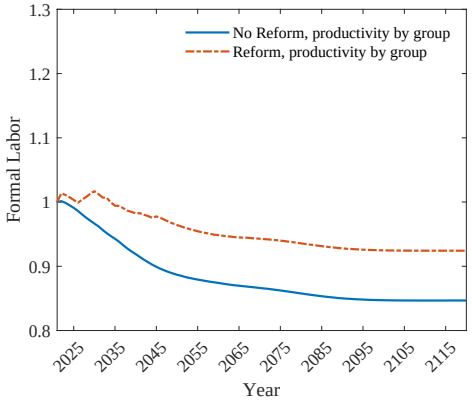
(a) Output



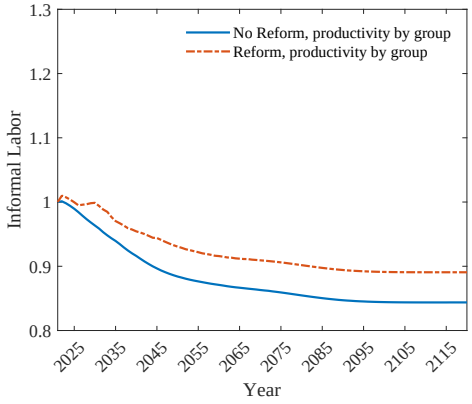
(b) Capital Stock



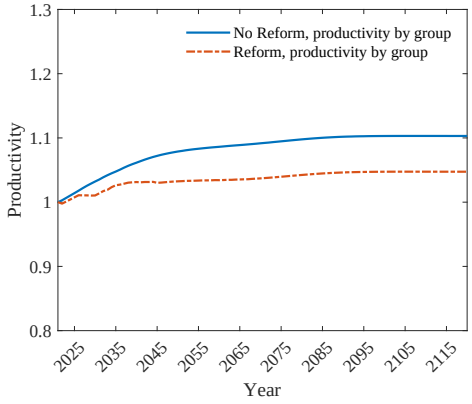
(c) Formal Labor



(d) Informal Labor



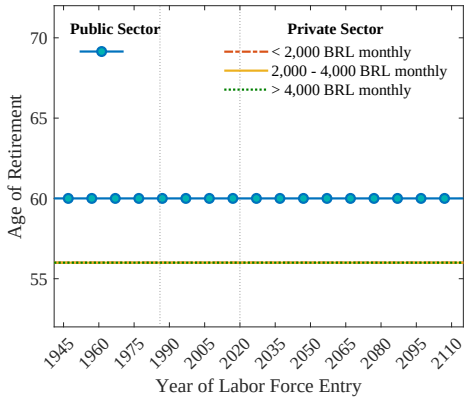
(e) Productivity



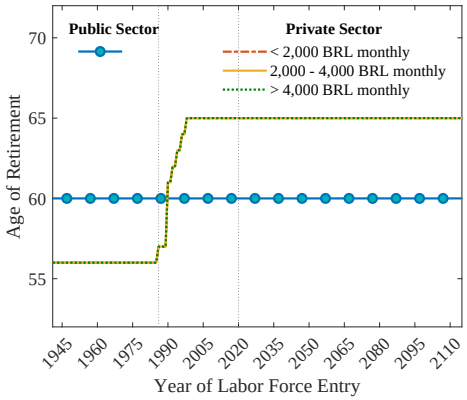
Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.

Figure 31: Retirement Age and Years of Contributions by Cohort: Same a, b

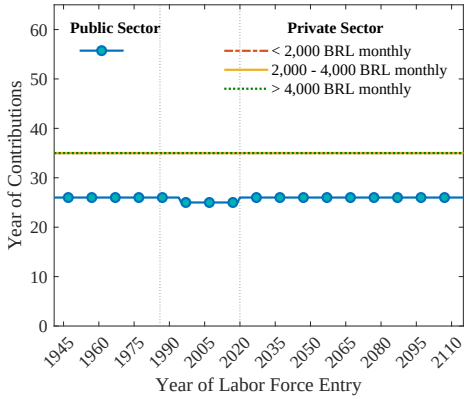
(a) Retirement Age, No Reform



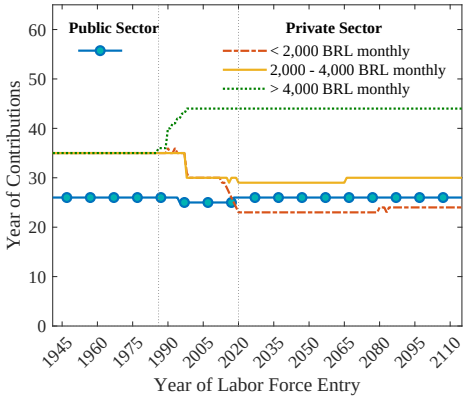
(b) Retirement Age, Reform



(c) Years of Contributions



(d) Years of Contributions

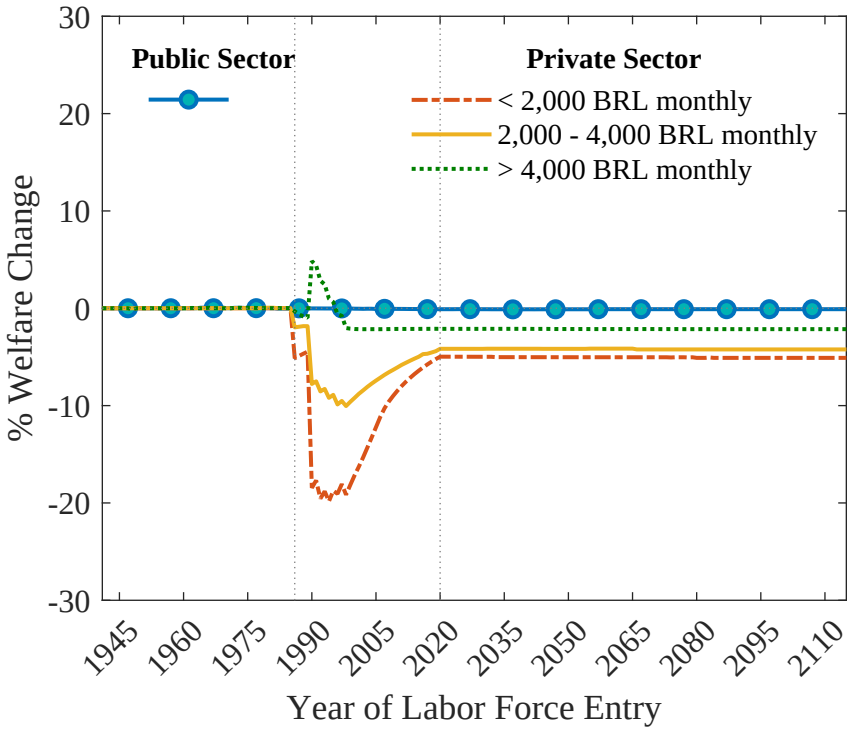


Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Welfare As with the experiment with flat productivity, the welfare impact of a reform is strongly influenced by the pattern of retirement age in the economy. Figure 32 shows the overall welfare impact and Figure 33 shows how this welfare is decomposed.

The welfare impact for public sector workers and the middle- and high-income private sector workers (overall and decomposed) in this experiment is, once again, similar to that of the baseline. Differences emerge for low-income workers- both in the transition and in the long-run. Both in the long-run and in the transition, these low-income workers experience welfare losses due to decreased leisure from the increased retirement age. This is the same as the higher-income private sector workers. Transitional generations of low-income workers experience welfare losses because they receive a pension for fewer years due to the increase in the retirement age but do not have savings to insure against the drop in consumption this causes. This is different than high-income workers. High-income private sector worker experience welfare gains due to consumption during the transition. These workers not only have savings but also are compensated with higher pensions during this time.

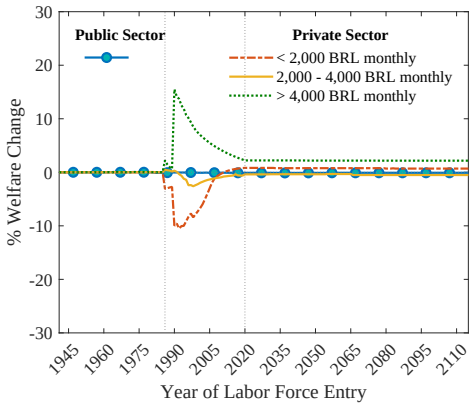
Figure 32: Welfare by Cohort: Same a, b



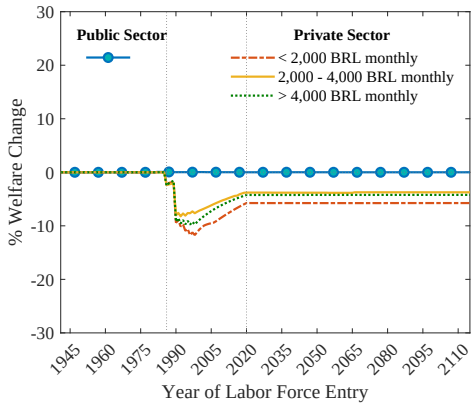
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Figure 33: Decomposing Welfare by Cohort: Same a, b

(a) Consumption



(b) Leisure



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Aggregates Aggregates for the case of same a, b are included in Figure 34. These variables evolve very similarly to the baseline. Quantitatively, there are a few differences. Capital stock, in Figure 34b, increases in both the case of no reform and the case of the reform. Relative to baseline, though, the capital stock increases more in the reform (the case of no reform is very similar to the baseline). Because all workers have the same parameters in the market labor supply function, the reform leads low- and middle-income workers to increase their savings and drives the capital stock higher. Similar to the baseline, in this economy, both formal and informal labor supply are higher when the reform occurs (Figures 34c and 34d). This increase in labor supply along with the increase in capital stock drive higher output (Figure 34a) when the reform occurs. Productivity, shown in Figure 34e, is similar both in the case of no reform and the reform.

Figure 35a shows how pension spending evolves throughout the transition path. A notable difference from the baseline, aggregate pension spending–both with and without the reform–are lower. Because workers operate under the same parameters, the ratio of formal hours to informal hours is higher for low-income workers and lower for middle- and high-income private sector workers. This means that pensions for high income individuals are lower than in the baseline and pull down aggregate pension spending. Despite the lower level of pension spending across both no reform and reform, the reform still decreases costs relative to the case of no reform. As in the baseline, the reform decreases aggregate pension spending by 3 percentage points of GDP.

L.4.2 Formal Sector Only

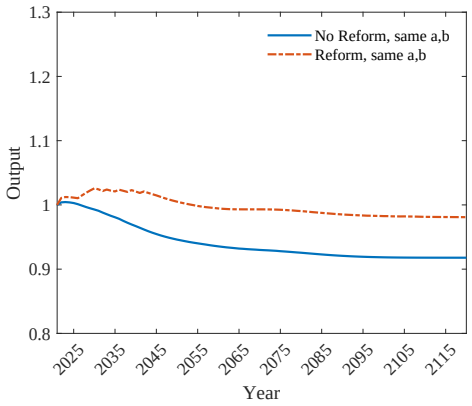
In this section, I consider if there is no informal sector in the economy. To achieve this, I set $a = 1, b = 1$ in the function $\Gamma(\cdot)$. This changes the function to:

$$\Gamma(h_{ft}, h_{it}) = h_{ft} \tag{22}$$

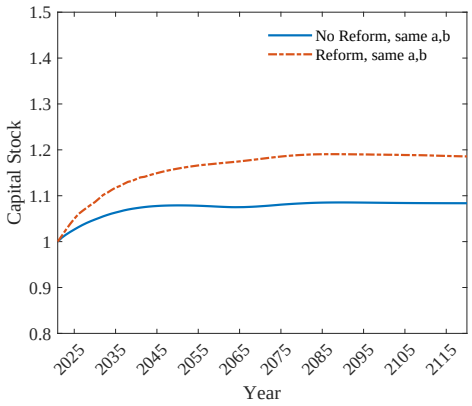
Numerically, I push the values of a and b as close as possible to one; these parameters are set to $a = 0.975$, $b = 0.901$. Under these parameters, formal labor supply of all individuals is 0.

Figure 34: Aggregates: Same a, b

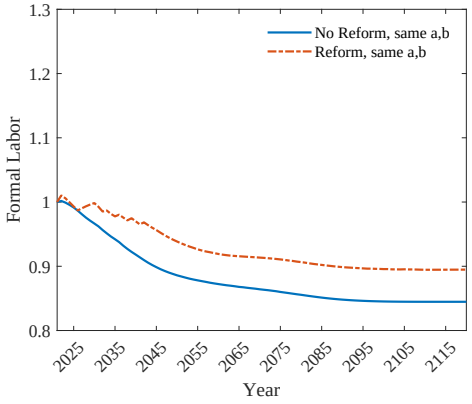
(a) Output



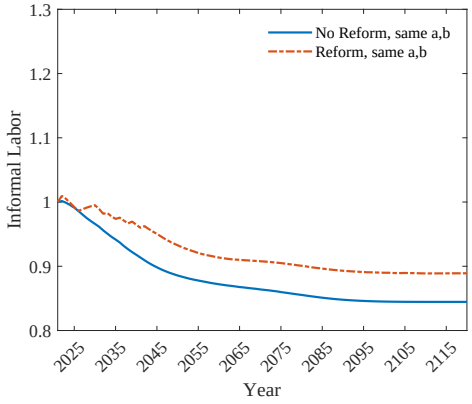
(b) Capital Stock



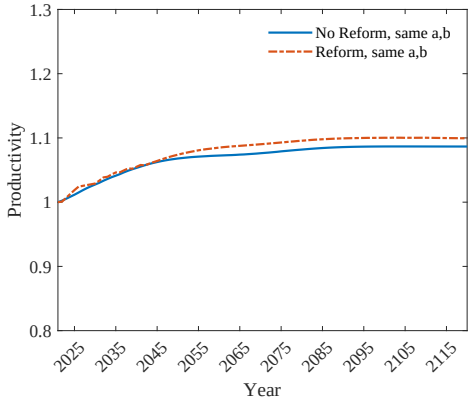
(c) Formal Labor



(d) Informal Labor



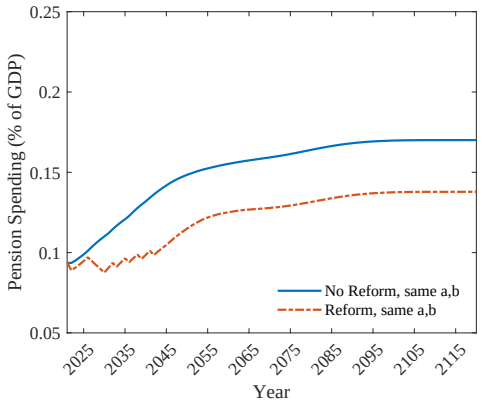
(e) Productivity



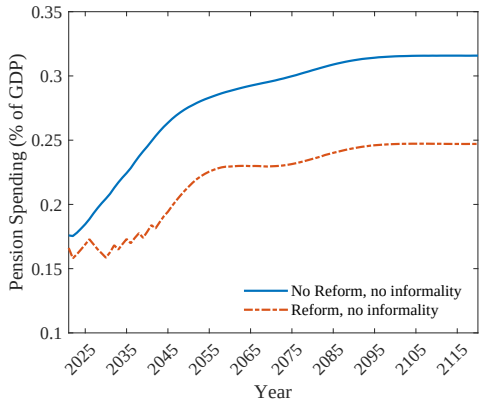
Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.

Figure 35: Aggregate Pension Spending: Informality Experiments

(a) Same a, b



(b) No Informality



Labor Supply Retirement age and years of contributions in Figure 36 exhibit the same patterns as in the case of the same a and b across income levels. Retirement ages for all private sector workers increase from 56 to 65 due to the reform. The impact on contribution levels differ by income. However, in contrast to other cases, the contributions of the highest income worker so not increase as much due to the reform.

Welfare The welfare impact of the reform in an economy without informality are shown in Figures 37 and 38. These graphs show the same pattern as has been in other experiments in which low-income workers also retire young. Namely, all private sector workers experience welfare losses-both in the transition and in the long-run–from the decreased leisure they experience due to the increase in the retirement age. However, the welfare impact due to changes from consumption differ based on whether workers are high or low income. In this experiment, both middle-income and high-income workers receive higher pensions in the early transition. Therefore, these workers experience welfare gains from the higher consumption. Low-income workers, on the other hand, receive only the minimum pension and, thus, experience welfare losses due to consumption drops in this period.

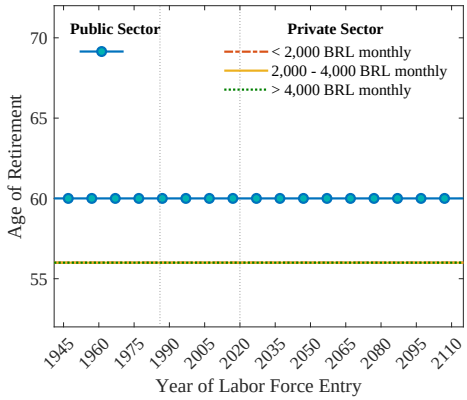
Aggregates Aggregates for the case of no informality are included in Figure 39. Note that there is no graph for informal labor since only the formal sector is included in this economy.

Capital stock, in Figure 39b, increases largely in response to the reform; the reform leads to much larger increase in capital stock in an economy without informality than in the baseline economy. By contrast, there is almost no impact on labor supply from the reform as the time series in Figure 39c is roughly the same across the cases of no reform and reform. The higher capital stock and similar labor supply lead to higher output (Figure 39a) and higher productivity (Figure 39d).

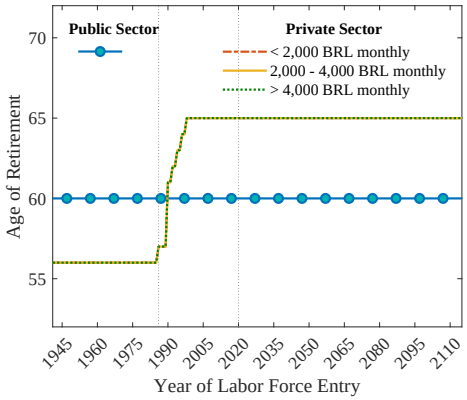
Figure 35b demonstrates how the reform impacts aggregate pension spending in an economy without informality. In contrast to the economy with informality but the same parameters, aggregate pension spending in the economy without informality is higher–both with and without the reform. Without the option of informality, average taxable income is higher. Therefore, pen-

Figure 36: Retirement Age and Years of Contributions by Cohort: No Informality

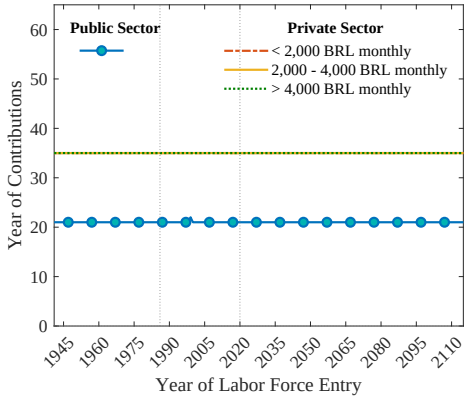
(a) Retirement Age, No Reform



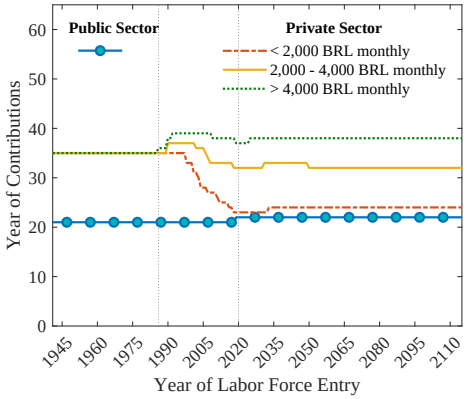
(b) Retirement Age, Reform



(c) Years of Contributions



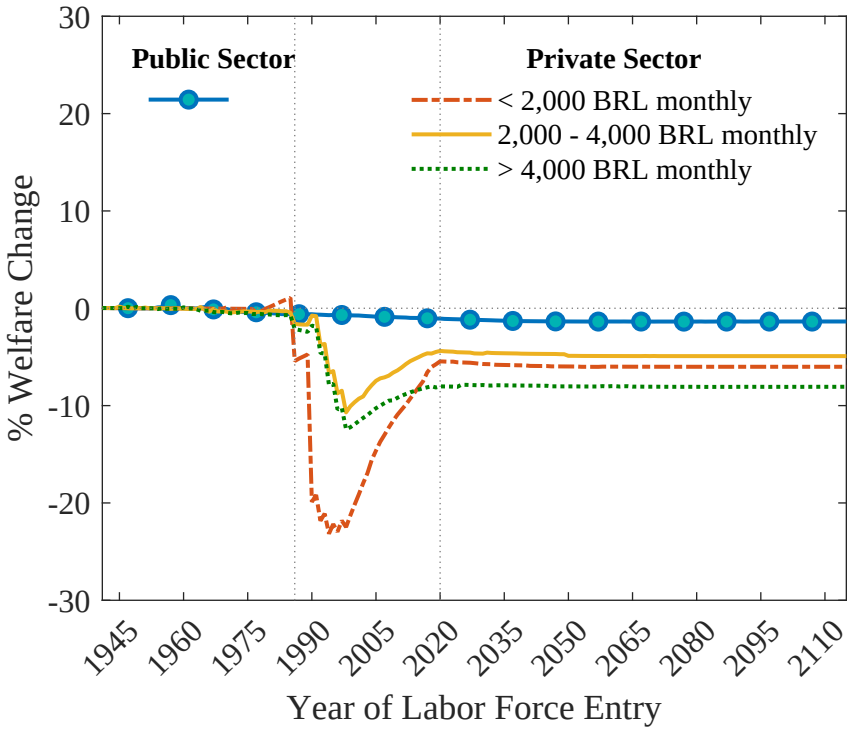
(d) Years of Contributions



Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

sions are larger when workers only participate in the formal sector. Therefore, when the reform is introduced it decreases the years in retirement and decreases costs. Because all private sectors previously retired young, the reform decreases pension spending more than it did in the baseline.

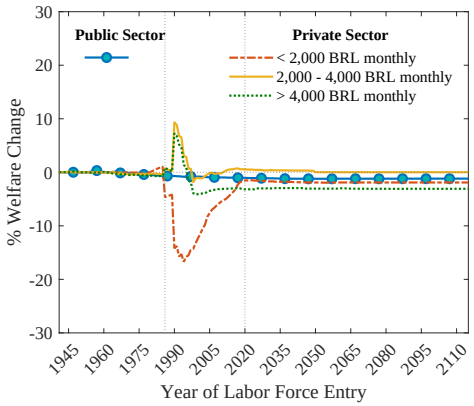
Figure 37: Welfare by Cohort: No Informality



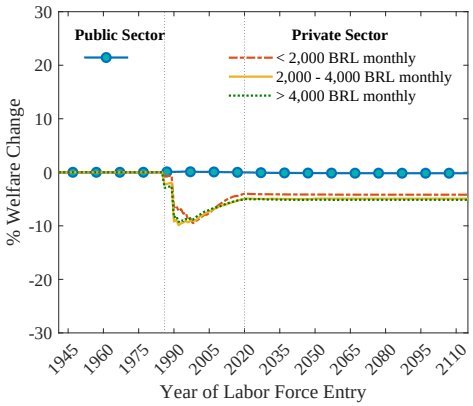
Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

Figure 38: Decomposing Welfare by Cohort: No Informality

(a) Consumption



(b) Leisure

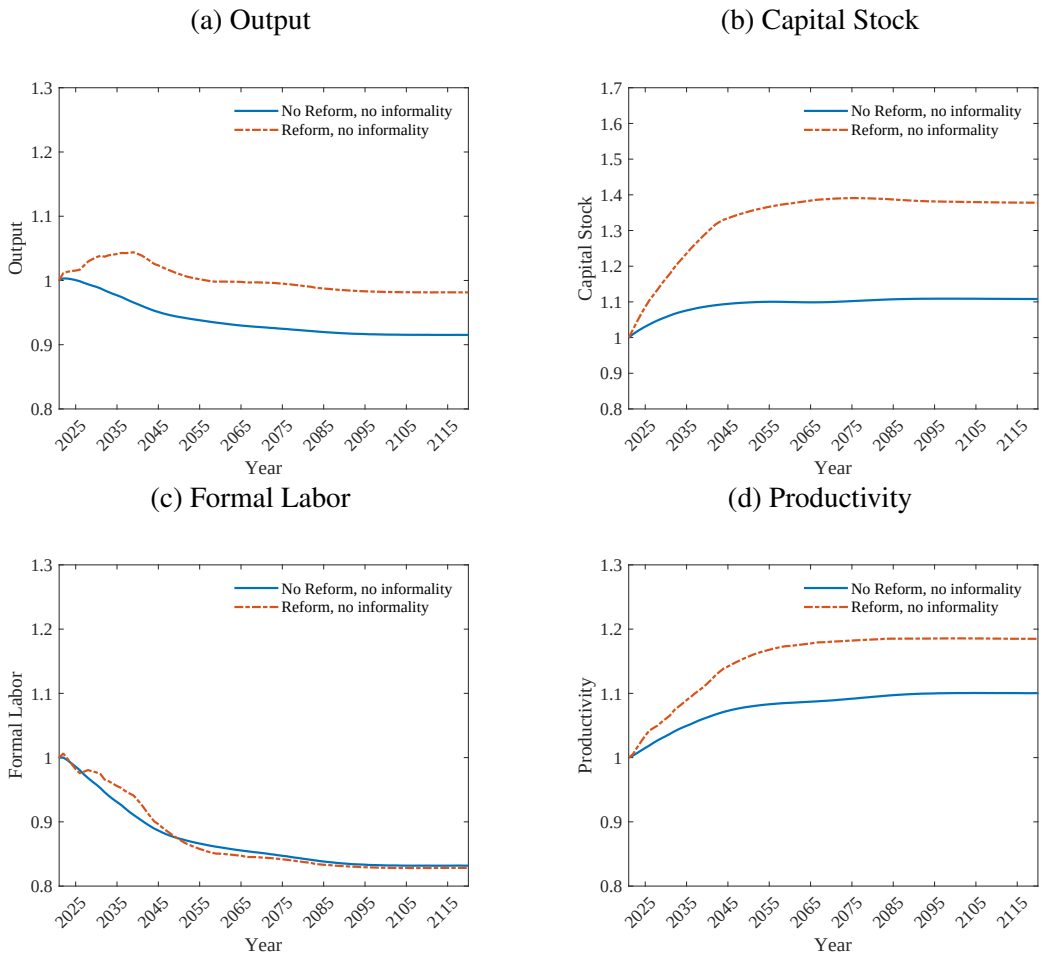


Note: vertical lines separate cohorts into those who are (from left to right) roughly retired (over age 56), working age, or not yet entered the labor force at the beginning of the transition path

References

McKiernan, K. (2021). Social security reform in the presence of informality. *Review of Economic Dynamics*, 40:228–251.

Figure 39: Aggregates: No Informality



Note: Output, capital stock, and labor are detrended by the population. Productivity is defined as output per efficient unit of labor. All series are shown relative to the pre-reform value.