The Role of the Part-Time Penalty in Shaping Retirement Decisions Across Occupations

Kanta Ogawa *

December 25, 2024

Abstract

Older male workers display varying retirement behaviors across different occupations, influenced significantly by the part-time penalty—wage reduction faced by part-time workers compared to their full-time counterparts. Many older individuals reduce their working hours, and in occupations with high part-time penalties, they tend to retire earlier, as observed in the Japanese Panel Study of Employment Dynamics (JPSED). This study develops a general equilibrium model that incorporates occupational choices, endogenous labor supply, highlighting that the impact on the retirement decision is amplified by the presence of assets and pensions. I find that reducing part-time penalties in high-penalty occupations improves long-term welfare by increasing both the extensive and intensive margins of older male workers. Similarly, income tax reforms targeting at pension recipients yield comparable positive outcomes. In contrast, conventional policies, such as raising the pension eligibility age by five years and cutting employees' pension benefits by half, are shown to decrease welfare.

*A second-year master student at Graduate School of Economics, The University of Tokyo.
Contact: ogawa-kanta319@g.ecc.u-tokyo.ac.jp, kantaogawa319@gmail.com
I would like to express my sincere gratitude to Professor Kosuke Aoki at the University of Tokyo for his invaluable guidance as my master's thesis advisor, and to Professor Sagiri Kitao at the National Graduate Institute for Policy Studies for her insightful advice. I also extend my thanks to the Recruit Works Institute, the Social Science Japan Data Archive, the Center for Social Research and Data Archives at the Institute of Social Science, The University of Tokyo, and the Panel Data Research Center at the Institute for Economic Studies, Keio University, for providing the data used in this research.

1 Introduction

In aging economies, understanding the factors behind retirement decisions [1] is crucial as the labor force is projected to decline. According to OECD [2023], the working-age population in OECD countries is expected to decrease by 11% by 2062 compared to 2022. This highlights the growing importance of developing occupation-specific policies, as the impact of this labor force reduction is likely to vary across different occupations.

Even today, some occupations, considered age-friendly, as noted by Acemoglu et al. [2022], have a high proportion of older workers, such as a taxi driver, while other occupations have a very small share of older workers, such as a programmer. However, the factors underlying these differences in age-friendliness remain unclear. This paper proposes that these stark variations are driven by differing degrees of part-time penalties. As shown Figure 1, there is a negative correlation between the share of workers aged 60 and older among those aged 40 and older and the part-time penalty [2].

While Rogerson and Wallenius [2013] argue that part-time penalties discourage older individuals from working part-time and often lead to permanent retirement without experiencing part-time roles, this paper investigates the sources of these heterogeneous retirement decisions across occupations, incorporating several novel features beyond the existing literature.

To begin with, this study incorporates occupational choices into the retirement decision model, building on the framework of Goldin [2014], which is developed to explain the narrowing gender wage gap [3]. Following Jang and Yum [2022] and Erosa et al. [2022], which formalizes her concept within an equilibrium, the key differences between nonlinear and linear occupations are defined as part-time penalties, experience premiums, occupation-specific productivity, and age penalties. These characteristics distinguish the occupations in the model. While the classification primarily hinges on part-time penalties, the other three factors also play significant roles in explaining economic outcomes and worker behavior.

Furthermore, this paper first clarifies that part-time penalties play a more significant role than they may initially seem, as they interact with assets and pension benefits. As Goldin [2014] notes, occupations with high part-time penalties are typically high-skilled, offering greater compensation. Workers in these occupations tend to accumulate larger assets and expect more generous pension benefits, raising their reservation wage. Older individuals often experience increasing labor disutility due to declining health, the desire to spend more leisure time with their spouses, or the pursuit of hobbies, making them more inclined to reduce their working hours [4]. In these circumstances,

[1] Blundell et al. [2016] provides an insightful survey of this complex field.

[2] The part-time penalty is defined in section 2.

[3] Bertrand et al. [2010] and Gicheva [2013] indicate that working shorter hours inhibits wage growth to account for gender wage gap.

[4] Another important consideration is highlighted by French and Jones [2012], which demonstrates that older individuals

workers in high part-time penalty occupations face significant wage reductions [5], making their potential earnings more likely to fall below their elevated reservation wage. Without switching to occupations with smaller part-time penalties, they tend to exit the labor market permanently, as shown in Figure 2. Permanent exits are most frequent among those aged 55 to 79, followed by job switches within the same occupation category. Faced with significant part-time penalties [6], these workers are highly likely to choose permanent retirement. In contrast, workers in occupations with smaller part-time penalties typically continue working, as the wage reduction upon transitioning to part-time work is smaller.

Building on this concept, I construct a general equilibrium model of overlapping generations with endogenous labor supply, capturing both extensive and intensive margins, as well as occupational choices. Agents make decisions regarding consumption and savings, balancing the desire to leave a bequest or prepare for longevity while facing a survival shock each period. Pension eligibility occurs unexpectedly at either age 60 or 65. This quantitative framework evaluates the impacts of policy reforms on different generations. In contrast to the literature [7], my model highlights how changes in retirement behavior can significantly affect the welfare of other generations through shifts in labor supply, saving behavior, and prices, considering a general equilibrium effect.

I leverage a rich data set, the Japanese Panel Study of Employment Dynamics (JPSED), to classify occupations and compute moments for a quantitative analysis. The JPSED covers more than 200 occupations and provides detailed personal information on each worker, including birth year, sex, education, work history, family status, and more. These detailed variables are valuable for conducting regressions to classify occupations. Additionally, I use the Japanese Household Panel Survey (JHPS/KHPS) to supplement the asset data that is not available in the JPSED.

I classify occupations as nonlinear or linear, regressing hourly wages on a quartic polynomial of working hours, controlling for age, birth year, family status, and more. I confirm that nonlinear occupations have low proportions of old workers, while linear occupations have higher rates of older individuals.

The calibration analysis identifies part-time penalties as the primary source of nonlinearity in

have higher labor elasticities compared to middle-aged workers.

[5] It is well-established that older individuals face wage declines. Mincer [1974] and Becker [1975] explain that older individuals invest less in human capital due to diminishing returns, leading to wage reductions. Additionally, Johnson and Neumark [1996] and Haider and Loughran [2010] suggest that older men often transition from full-time jobs with higher compensation to lower-paying part-time positions, influenced by social security regulations and the desire for less demanding work. Aaronson and French [2004] further demonstrates that transitioning to part-time jobs results in wage reductions for individuals in their early sixties.

[6] Ameriks et al. [2020] examines a similar issue from a different angle, noting that the scarcity of jobs with flexible working conditions discourages older individuals from continuing to work.

[7] While French [2005] and Fan et al. [2022] estimate life-cycle models to analyze retirement behavior, their approaches focus on a partial equilibrium. Similarly, Imrohoroğlu and Kitao [2012] demonstrates that social security reforms significantly affect the extensive and intensive margins of older individuals but do not incorporate occupational choices or part-time penalties.

the model, followed by varying experience premiums across occupations, which reflect the increase in compensation from working additional periods. I also conduct counterfactual experiments to assess the impacts of policies aimed at increasing the labor supply of older individuals. The results indicate that eliminating the earnings test in pension rules [8] raises the intensive margin of older males by only 2.539% [9], while having minimal impact on welfare. Extending pension eligibility [10] and cutting pension benefits [11] increases labor supply but slightly reduces output, leading to a welfare loss for all generations. When the pension eligibility age is extended, the capital supply decreases by 2.366% in contrast to Imrohoroğlu and Kitao [2012] as workers adjust their retirement timing and experience flatter income profiles over time. Conversely, reducing the part-time penalties in nonlinear occupations increases labor supply in the nonlinear occupations by 2.247% and enhances long-term welfare in terms of consumption equivalence. Policies such as raising tax credits and exempting pensions from income tax are also effective in boosting labor supply across both types of occupations, increasing output, and improving welfare.

Section 2 discusses empirical facts, and section 3 elaborates on the model. Section 4 presents the calibration results. Section 5 details the counterfactual experiments, and section 6 concludes this paper.

[8] Eliminating the earnings test has been shown to effectively increase the labor supply of older workers, particularly older males, in countries such as the U.S., Canada, and the U.K. (U.S.: Blinder et al. [1980]; Friedberg [2000]; Song and Manchester [2007]; Haider and Loughran [2010]; Gelber et al. [2013], Canada: Baker and Benjamin [1999], U.K.: Disney and Smith [2002]). Notably, Disney and Smith [2002] demonstrates that such reforms have a significant impact on the intensive margin, leading older individuals to work more hours.

[9] While Shimizutani et al. [2008] finds that the reform to earnings test in Japan in 1985 had only limited effect on the labor supply of old workers, Shimizutani [2013] implies the earnings test discourages the labor supply of the old individuals, utilizing the direct survey response.

[10] Numerous analyses also examine the extension of retirement ages across different countries and verify the resulting increase in the extensive margin of older workers (U.S.: Pingle [2006]; Mastrobuoni [2009], U.K.: Blundell and Emmerson [2003]; Cribb et al. [2013], Austria: Staubli and Zweimüller [2013]; Atalay and Barrett [2015], Switzerland: Hanel and Riphahn [2012]; Lalive and Staubli [2015]).

[11] Several studies indicate that past pension reforms, including benefit reductions, have increased the labor force participation rate of older individuals (Anderson et al. [1999]; Gustman and Steinmeier [2009]; Blau and Goodstein [2010]; Brown [2013]).

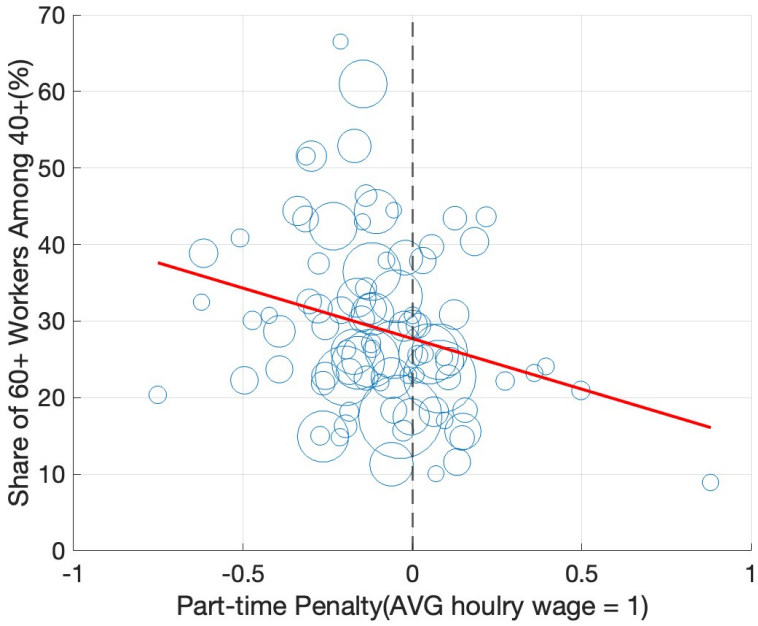


Figure 1: Part-time Penalty and Rate of workers between 60 and 79 years old: Male, 2015-2019[12]

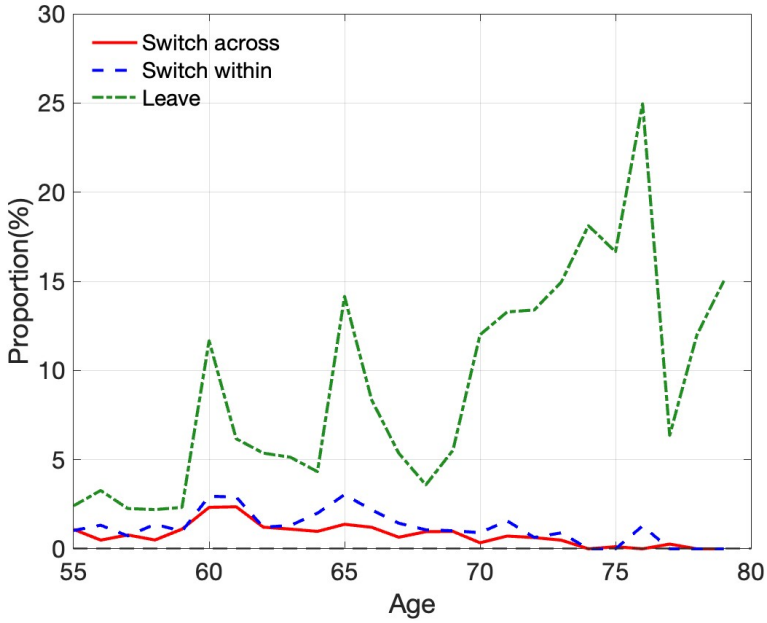


Figure 2: Unconditional Proportion of Workers' Choices After Quitting Jobs: Male, 2015-2019[13]

[12]The size of the circle is proportional to the number of male workers between 25 and 79 years old in each occupation.

[13]"Leave" represents the proportion of workers who exit the labor force after leaving their occupation. "Switch across" refers to transitions between different occupation types; for example, a nonlinear worker moving to a linear occupation. "Switch within" indicates job changes within the same occupation category; for instance, a nonlinear worker moving to another nonlinear job.

2 Empirical Analysis

2.1 Data

The Japanese Panel Study of Employment Dynamics (JPSED), collected by the Recruit Works Institute and released by the University of Tokyo, provides data for classifying occupations and calibrating the model. Covering over 100 individual attributes from 2015 to 2022, it includes approximately 50,000 annual observations. For classification, all valid observations are used with controls for time and sex. For calibration, the analysis focuses on males aged 25–104 from 2015 to 2019, avoiding the COVID-19 pandemic's impact on retirement decisions.

Household asset data is supplemented with the Japanese Household Panel Survey (JHPS/KHPS), with KHPS starting in 2004 and JHPS in 2009. Asset moments are calculated using data from 2012 to 2019, including financial and housing assets, while pre-2015 data increases observations for older individuals. KHPS and JHPS provide approximately 3,000 and 2,500 annual observations, respectively, ensuring alignment with model calibration.

2.2 Occupational Classification Strategy

I classify occupations using regression analysis, addressing limitations in methods used by Erosa et al. [2022] and Jang and Yum [2022], which categorize occupations based on male working hours. This approach is unsuitable for Japan, where most males aged 25–59 work full-time, leading to unintended results. For example, truck drivers and barbers, with longer working hours, often exhibit linear wage-hour relationships, while researchers and IT engineers, with shorter hours, show nonlinear patterns. To resolve this, I adopt a regression-based method, controlling for factors like age, sex, and family status, using data from both sexes aged 25–79 to capture more part-time workers.

I conduct the classification in the following procedure:

1. For each of the more than 200 occupations, I regress hourly wages on a quartic polynomial of weekly working hours, controlling for age (as a polynomial), sex, education, marital status, child status, residential area, and time-fixed effects. Occupations with fewer than 200 observations are excluded.

2. I calculate the residualized hourly wage difference between individuals working 10 hours per week and those working 40 hours per week. I define this wage difference standarized by the average hourly wage of males aged 25-79 as a part-time penalty.

3. I classify the top 50 % of occupations with the largest part-time penalties as nonlinear, and

the remainder as linear [14].

For example, IT engineers, researchers, pharmaceutical sales representatives, and banking sales representatives are classified as nonlinear occupations. In contrast, construction workers, cooks, and character and CG designers are classified as linear occupations.

Figure 3 illustrates the change in hourly wage, normalized to the hourly wage at 10 hours per week, between nonlinear and linear occupations. The figure shows that hourly wages increase more rapidly with working hours rise in nonlinear occupations, which aligns with the original concept of these occupational categories. Unlike Goldin [2014], who assumes no wage changes in linear occupations, I allow for minor wage increases.

The data supports the hypothesis that workers in nonlinear occupations face high part-time penalties, leading to earlier retirement compared to those in linear occupations. As shown in Figure 4, the share of nonlinear occupations among working males steadily declines after age 60, while the share of linear occupations rises. Table 1 shows that non-working rates increase sharply from 4.74% (ages 25–59) to 77.10% (ages 70–79). Before age 60, most workers in both occupation types work full-time. After age 60, the share of workers decreases more sharply in nonlinear occupations, while linear occupations see a smaller decline as workers continue with reduced hours.

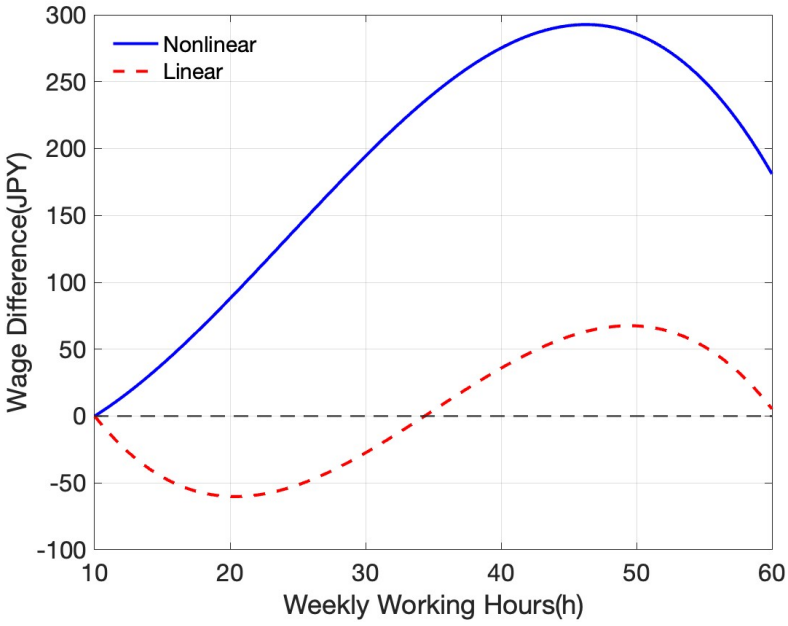


Figure 3: Hourly Wage Change over Working Hours (nonlinear vs. linear)

[14] Nearly all occupations classified as nonlinear exhibit positive part-time penalties, whereas linear occupations typically have negligible or negative penalties.

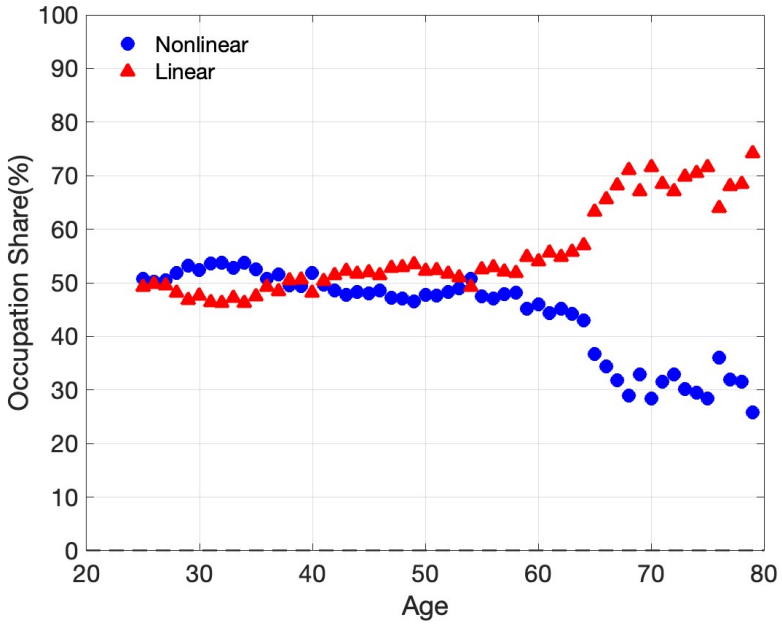


Figure 4: Change of Conditional Occupation Share over Age(nonlinear vs. linear)

Table 1: Working Hours Distribution by Age: Proportion(%) [15]

			Age			
Annual Working Hours	25-59		60-69		70-79	
Not working	4.743		30.56		77.10	
			Occupation			
Working	Nonlinear	Linear	Nonlinear	Linear	Nonlinear	Linear
(0, 1000)	0.2373	0.5963	1.499	3.278	1.411	3.632
[1000, 1500)	0.5223	1.325	2.662	5.871	1.439	3.699
[1500, 2000)	5.194	4.753	7.268	8.567	1.653	3.198
[2000, 2500)	28.61	25.58	13.42	18.82	2.071	4.140
2500 ≤	12.71	15.74	2.505	5.549	0.42143	1.236
Subtotal	47.27	47.99	27.35	42.09	6.574	15.91
Total	95.26		69.44		22.48	

3 Model

In this section, I present the details of the model. I integrate the occupational choice model developed by Jang and Yum [2022] into the retirement decision framework to explain the heterogeneity in the proportion of older workers among overall employees across different occupations.

[15]The table provides an unconditional proportion of workers in each category. For example, between the ages of 25 and 59, 4.743% of individuals do not work, while 95.26% are employed. 47.27% of agents work in nonlinear occupations, and 0.2373% of individuals work less than 1,000 hours per year in nonlinear occupations .

3.1 Demographics

A continuum of males is born each year at age 25 (t=1) and lives until age 104 (t=80). A fraction of these individuals begins receiving pension benefits at age 60 (t=36), while the remainder start at age 65 (t=41). Pension eligibility is determined at age 60 as a random shock, remaining unknown until that point. All agents retire from the labor force by age 80 (t=56). Each agent faces a survival shock in every period. Upon death, their bequests are evenly distributed among the remaining survivors.

3.2 Preferences

Each agent has preferences over consumption, labor supply, and assets which are denoted by c, $h.$, and a, respectively. They decide whether to work and, if working, select occupations. Utility is derived from consumption, while disutility arises from labor supply, which consists of two components: a fixed cost of working, ξ, and labor disutility, Φ, which starts to increase at $R+1$. All agents have this utility function:

$$u(c,h;\phi,t,a_0) = \frac{c^{1-\sigma}}{1-\sigma} - \Phi(t)\frac{h^{1+\frac{1}{\gamma}}}{1+\frac{1}{\gamma}} - \xi\mathbb{1}\{h>0\}$$

where the coefficient of labor disutility is given by $\Phi_i(t) = \phi_i + \kappa(t-R)\mathbb{1}\{t>R\}$ [16], and the fixed cost of working is expressed by ξ.

Agents also have a bequest motive, and all bequests are equally distributed among surviving agents. This model focuses on accidental bequests [17] and excludes the inheritance of earnings ability and inter-vivo transfers. The utility derived from leaving a bequest is modeled as:

$$\mu(a') = \mu_1\left(1+\frac{b(a')}{\mu_2}\right)^{1-\sigma}$$

where $b(a')$ denotes the after-tax bequest. μ_1 represents the agent's concern for leaving bequests, and μ_2 indicates the extent to which bequests are considered luxury goods.

3.3 Pension

Pension benefits are composed of two terms: the national pension, $\underline{b}$, which is distributed equally to all agents, and employees' pension insurance, which is based on the agent's past earnings. The

[16] I set R=35, which denotes 59 years old in real terms, which means that the labor disutility starts to increase when the agent turns 60 years old.

[17] I refer to De Nardi [2004] to formulate this bequest motive.

mean of the agent's past labor earnings is updated each period using the following equation,subject to an upper bound on labor earnings, $\bar{e}$, when calculating pension benefits. Until age 70, e is updated according to the rules of employees' pension insurance.

$$ssb(e) = \underline{b} + \rho e$$
$$e = \frac{e_{-1} \times (t-1) + \min\{\lambda, \bar{e}\}}{t}$$

, where λ denotes today's post-tax labor income.

3.4 Efficiency Labor

Each agent is compensated by firms based on their efficiency labor, which depends on several factors. A working agent provides an effective labor supply to the representative firm, and wages are paid per unit of effective labor. If an agent of age t and experience x works in occupation j for hours h per week, their income is given by:

$$w_j \underbrace{m_j(\eta_1) g_j(h) z_j(x, j_{-1}, t) f_j(t)}_{\text{Effective Labor Supply}}$$

First, the worker selects an occupation based on the occupation-specific productivity, $m(\eta_1)$ [18]. A worker draws η_1, an idiosyncratic value, at birth, which remains constant throughout their lifetime. If a worker is well-suited for occupation j, they typically remain in the same job until retirement. The occupation-specific productivity is defined as:

$$m(\eta_j) = \begin{cases} e^{\eta_1} & (j = \text{NL}) \\ 1 & (j = \text{L}) \end{cases}$$

Second, the part-time penalty is governed by the function $g_j(h)$, which depends on labor supply. As an agent works more hours, their productivity increases, with the degree of this increase varying across occupations. In general, productivity rises more significantly in nonlinear occupations compared to linear ones. The following functional form is assumed when calibrating the parameters:

$$g_j(h) = h^{1+\theta_j}$$

where $\theta_j > -1$.

[18] NL and L refer to nonlinear and linear occupations, respectively.

Moreover, productivity also depends partly on experience within the occupation. A worker accumulates one unit of experience for each period of work [19].

$$z_j(x, j_{-1}, t) = \begin{cases} 1 + \underbrace{\Omega_j \min\{x, \bar{x}_j\}}_{\substack{\text{Experience} \\ \text{Premium}}} & (j = j_{-1}) \\ 1 & (j \neq j_{-1}) \end{cases}$$

Experience is updated according to the rule: $x = x_{-1} + 1$ if $j = j_{-1}$ and $x = 0$ if $j \neq j_{-1}$, where x_{-1} represents prior experience. Each unit of an experience adds Ω_j units of an experience premium until reaching the upper bound, $\bar{x}_j$ [20], which varies across occupations. As long as the worker remains in the same occupation, they continue to accumulate experience. However, if the worker switches to a different occupation, their experience resets, starting from $x = 0$.

Lastly, once an agent reaches age $R+1$ [21], they incur an age-penalty, representing wage reduction typically associated with the demotion after retirement age. Workers are often reassigned to lower positions, leading to a significant reduction in their wages. This penalty is independent of the worker's experience and continues until they reach age $\bar{R}_j (> R)$ [22].

$$f_j(t) = \exp\left(-\pi_j(\min\{t, \bar{R}_j\} - R)\mathcal{I}_{t>R}\right)$$

3.5 Household Problem

Using these features, I construct a household problem that accounts for both the extensive and intensive margins of labor supply, allowing workers to choose their occupations. Productivity increases with age until experience reaches $\bar{x}_j$ after which it begins to decline at age $R+1$. Pension eligibility starts unexpectedly for some agents at age 60, while others begin receiving benefits at age 65, with amount based on past earnings. All agents retire by age 80 and live up to 104, facing survival shocks.

First, I describe the problem faced by agents between the ages of 25-79. Each period, agents decide on their consumption, next-period assets, labor supply, and, if working, their occupations in the current period. In this problem, a worker decides whether to work in period t, given the

[19] The process of accumulating experience does not require full-time work, as only 8.9% of males between 25 and 59 work less than 35 hours per week in the data. This full-time work constraint would be necessary if the focus were on analyzing the gender wage gap.

[20] From the data, I set $x_{NL} = 35$ and $x_L = 29$, which, respectively, denote 59 and 53 years old.

[21] This is equal to the age assigned for labor disutility function, Φ.

[22] I set $\bar{R}_j = 37$ (61 years old) to match the actual wage decline for old workers. In the data, the sharp wage decline occurs between 60 and 61 years old.

state $(a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p)$. Here, a denotes the current assets, and x_{-1} represents the years of experience in the current occupation. The variable j_{-1} determines the experience premium in combination with x_{-1}, because if a worker switches occupations, their experience is reset to zero, and they must start from scratch. The variable ϕ represents an idiosyncratic coefficient for labor disutility function, Φ, and η_1 is a parameter in the nonlinear occupation-specific productivity, which determines the worker's suitability for each occupation. The variable t represents the worker's age, and e_{-1} is the mean of the worker's past earnings, which determines the amount of pension benefits. The variable p represents pension eligibility: if $p = 1$, the agent is eligible for pension benefits. All younger agents are ineligible, meaning $p = 0$. A fraction of the population starts receiving a pension at age sixty, while others become eligible at age sixty-five. Agents do not know their exact pension eligibility age until they turn sixty and begin receiving pension benefits if eligible.

The post-income tax function, $\mathcal{Y}(\cdot)$, takes three inputs: financial before-tax income, labor income, and pension benefits. I replicate Japan's 2019 tax system, as there were no significant tax reforms during the period used for calibration.

People make these decisions simultaneously every period, solving the following maximization problem:

$$V^Y(a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p) = max\Big\{N(a, \phi, \eta_1, t, e_{-1}, p), W(a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p)\Big\}$$

Here, $N(\cdot)$ and $W(\cdot)$ correspond to the value functions of not working and the value of working, respectively. The decision to work or not is represented by $n \in \{NW, W\}$, where NW indicates not working and W indicates working.

Next, if working, an agent selects an occupation. J_j is the value of working in occupation j, where $j = NL$ and $j = L$ represent nonlinear and linear occupations, respectively. For convenience, I also denote $j = NW$ to represent a non-worker.

$$W(a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p) = max\Big\{J_{NL}(a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p), J_L(a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p)\Big\}$$

The value function of occupation j is clearly defined by:

$$\begin{aligned} &J_j(a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p) \\ &= max_{c,a' \geq 0, h \in [0,1]} \Big\{u(c, h) + \Big(1 - S(t)\Big)\mu(a') + \beta S(t)\mathbb{E}\Big[V^Y(a', x, j, \phi, \eta_1, t+1, e, p')\Big]\Big\} \end{aligned}$$

subject to:

$$c + a' = a + Tr + B + \mathcal{Y}\Big(ra, w_j m_j(\eta_1) g_j(h) z_j(x, j_{-1}, t) f_j(t), \mathcal{I}_{p=1} ssb(e)\Big)$$

, where β denotes a discounted factor.

In the budget constraint, Tr and B denote the public lump-sum transfer and bequest from the deceased, respectively. They survive to the next period with a probability $S(t)$ and die with a probability $1 - S(t)$, leaving a bequest. The agent earns income from assets, labor, and, if eligible, a pension. They allocate disposable income—after paying social security contributions and taxes on labor and financial income—towards consumption and asset accumulation.

Alternatively, if not working, the agent faces the value of not working:

$$N(a, \phi, \eta_1, t, e_{-1}, p) = max_{c,a\geq 0}\Big\{u(c, 0) + \Big(1 - S(t)\Big)\mu(a') + \beta S(t)\mathbb{E}\Big[V^Y(a', 0, 0, \phi, \eta_1, t + 1, e, p')\Big]\Big\}$$

subject to:

$$c + a' = a + Tr + B(t) + \mathcal{Y}\Big(ra, 0, \mathcal{I}_{p=1} ssb(e)\Big)$$

Lastly, after age 80, agents no longer work and rely solely on interest from assets and pension benefits, which continue to depend on their past earnings.

$$V^O(a, t, e_{-1}, p') = max_{c,a\geq 0}\Big\{u(c, 0) + \Big(1 - S(t)\Big)\mu(a') + \beta S(t)\mathbb{E}\Big[V_O(a', t + 1, e, p')\Big]\Big\}$$

subject to:

$$c + a' = a + Tr + \mathcal{Y}\Big(ra, 0, \mathcal{I}_{p=1} ssb(e)\Big)$$

3.6 Representative Firm

I elaborate on the settings of the production sector. The representative firm demands capital (K), nonlinear labor, and linear labor.

Nonlinear labor and linear labor for occupations are denoted by $E_1 L_1$ and $E_2 L_2$, respectively, while K represents the firm's capital demand.

$$max_{E_1 L_1, E_2 L_2, K} Y - w_1 E_1 L_1 - w_2 E_2 L_2 - (r + \delta)K$$

,where

$$\begin{aligned} Y &= AK^{\alpha}(EL)^{1-\alpha} \\ EL &= \left[\nu(E_1L_1)^{\frac{\psi-1}{\psi}} + (1-\nu)(E_2L_2)^{\frac{\psi-1}{\psi}}\right]^{\frac{\psi}{\psi-1}} \end{aligned}$$

The first-order conditions are as following:

$$\begin{aligned} r &= \alpha\left(\frac{EL}{K}\right)^{1-\alpha} - \delta \\ w_1 &= (1-\alpha)\left(\frac{K}{EL}\right)^{\alpha}\nu\left(\frac{EL}{E_1L_1}\right)^{\frac{1}{\psi}} \\ w_2 &= (1-\alpha)\left(\frac{K}{EL}\right)^{\alpha}(1-\nu)\left(\frac{EL}{E_2L_2}\right)^{\frac{1}{\psi}} \end{aligned}$$

3.7 Stationary Competitive Equilibrium

I assume that the initial asset a_0 is zero, and I define individual states, s_Y and s_O, as $s_Y \equiv (a, x_{-1}, j_{-1}, \phi, \eta_1, t, e_{-1}, p) \in \mathbf{S}^Y$ and $s_O \equiv (a, t, e_{-1}, p) \in \mathbf{S}^O$, respectively, where the state spaces, $\mathbf{S}^Y$ and $\mathbf{S}^O$, are $\mathbf{S}^Y \equiv \mathbf{A} \times \mathbf{X} \times \mathbf{J} \times \Phi \times \eta \times \mathbf{T} \times \mathbf{E} \times \mathbf{P}$ and $\mathbf{S}^O \equiv \mathbf{A} \times \mathbf{T} \times \mathbf{E} \times \mathbf{P}$.

The equilibrium follows a standard definition, where both the capital and two labor markets are clear. In detail, the stationary competitive equilibrium consists of factor prices (r, w_1, w_2), allocations to agents,$\{c_Y(s_Y), a'_Y(s_Y), h_Y(s_Y))\}_{s_Y \in \mathbf{S}^Y}$ and $\{c_O(s_O), a'_O(s_O)\}_{s_O \in \mathbf{S}^O}$, working decision rules of the agents $\{n(s_Y), j(s_Y)\}_{s_Y \in \mathbf{S}^Y}$, value functions, $\{V^Y(s_Y), N(s_Y), W(s_Y)\}_{s_Y \in \mathbf{S}^Y}$ and $\{V^O(s_O)\}_{s_O \in \mathbf{S}^O}$ allocations to firms (K, E_1L_1, E_2L_2), and probability measures , $F_Y(\cdot)$, on the Borel set $\mathrm{B}(\mathbf{S}^Y)$ such that $F_Y(\cdot) : \mathbb{B}(\mathbf{S}^Y) \to [0, 1]$ and , $F_O(\cdot)$, on the Borel set $\mathbb{B}(\mathbf{S}^O)$ such that $F_O(\cdot) : \mathbb{B}(\mathbf{S}^O) \to [0, 1]$.

1. Given (r, w_1, w_2), policy functions $\{c_Y(s_Y), a'_Y(s_Y), h_Y(s_Y))\}_{s_Y \in \mathbf{S}^Y}$, $\{c_O(s_O), a'_O(s_O)\}_{s_O \in \mathbf{S}^O}$ and $\{n(s_Y), j(s_Y)\}_{s_Y \in \mathbf{S}^Y}$ and value functions $\{V^Y(s_Y), N(s_Y), W(s_Y)\}_{s_Y \in \mathbf{S}^Y}$ and $\{V^O(s_O)\}_{s_O \in \mathbf{S}^O}$ solve the household problem.

   The working decision rules are determined by

$$\begin{aligned} \text{Extensive Margin} : n(s_Y) &= argmax\{N(s_Y), W(s_Y)\} \\ \text{Occupational Choice} : j(s_Y) &= argmax\{J_{NL}(s_Y), J_L(s_Y)\} \end{aligned}$$

   where $n(s_Y) \in \{NW, W\}$ and $j(s_Y) \in \{NL, L\}$.

2. Given (r, w_1, w_2), the representative firm solves the profit maximization problem as defined above.

3. The government satisfies the balanced budget constraint by collecting income taxes, inheritance taxes, and social security payments, and distributing lump-sum transfers and pension benefits to individuals.

$$\underbrace{Tax^{\text{Labor}}}_{\text{Labor Income Tax}} + \underbrace{Tax^{\text{Asset}}}_{\text{Financial Income Tax}} + \underbrace{Tax^{\text{Bequest}}}_{\text{Inheritance Tax}} + \underbrace{SSP}_{\substack{\text{Social Security}\\ \text{Payment}}}$$

$$= \underbrace{\int \Big(\underbrace{Tr}_{\substack{\text{lump-sum}\\ \text{transfer}}} + \underbrace{ssb(e)\mathcal{I}_{p=1}}_{\text{Pension benefit}} \Big) F_Y(ds_Y)}_{\text{between 25 and 79 years old}} + \underbrace{\int \Big(Tr + ssb(e)\mathcal{I}_{p=1} \Big) F_O(ds_O)}_{\text{between 80 and 104 years old}}$$

4. All the bequest is allocated equally to all the individuals, and this equation holds.

$$\int \Big(1 - S(t)\Big) b(a') F(ds_Y) + \int \Big(1 - S(t)\Big) b(a') F(ds_O) = B\left(\int S(t) F_Y(ds_Y) + \int S(t) F_O(ds_O) \right)$$

5. Both asset and labor markets are cleared.

   - Asset Market Clearing Condition:

$$K^D = \int a'_Y(s_Y) F_Y(ds_Y) + \int a'_O(s_O) F_O(ds_O)$$

   - Labor Market Clearing Condition: for each $j \in \{NL, L\}$,

$$E_j L_j = \int \mathbb{1}\Big\{ j(s_Y) = j \Big\} m_j(\eta_1) g_j(h) z_j(x, j_{-1}, t) f_j(t) h(s_Y) dF_Y(s_Y)$$

6. The probability measures are consistent with the agent's optimal choices, and therefore, these equations hold.

$$\forall B_Y \in \mathbb{B}(\mathbf{S}_Y), F_Y(B_Y) = \frac{\int_{(a',\min\{x_{-1}+1,n_j\},j,\phi,\eta_1,t+1,e)\in B_Y} \mathbb{1}\left\{n(s_Y) = W\right\}\mathbb{1}\left\{j(s_Y) = j_{-1}\right\}S(t)F_Y(ds_Y)}{\int_{s_Y\in\mathbf{S}_Y} S(t)F(ds_Y)}$$
$$+ \frac{\int_{(a',1,j,\phi,\eta_1,t+1,e)\in B_Y} \mathbb{1}\left\{n(s_Y) = W\right\}\mathbb{1}\left\{j(s_Y) \neq j_{-1}\right\}S(t)F_Y(ds_Y)}{\int_{s_Y\in\mathbf{S}_Y} S(t)F(ds_Y)}$$
$$+ \frac{\int_{(a',0,NW,\phi,\eta_1,t+1,e)\in B_Y} \mathbb{1}\left\{n(s_Y) = NW\right\}S(t)F_Y(ds_Y)}{\int_{s_Y\in\mathbf{S}_Y} S(t)F(ds_Y)}$$
$$\forall B_O \in \mathbb{B}(\mathbf{S}_O), F_O(B_O) = \frac{\int_{(a',t+1,e)\in B_O} S(t)F_O(ds_O)}{\int_{s_O\in\mathbf{S}_O} S(t)F_O(ds_O)}$$

4 Calibration

4.1 Externally Set Parameters

I calibrate certain parameters exogenously to replicate agents' retirement decisions, drawing from Japan's economic institutions and relevant literature.

The capital depreciation rate is set at 8.8%. To determine the threshold between full-time and part-time work, $\mathcal{F}$, I analyze the distribution of hourly wages across working hours, noting sharp wage increase in wages beyond 35 hours per week. An upper bound on working hours, $\bar{h}$, of 105 hours per week.

The tax and social security system reflects Japan's economic institutions from 2015 to 2019. National pension benefits and tax rates are based on regulations: the base pension benefit, $\underline{b}$, is set at 65,008 JPY per month, and the financial tax rate, τ_r, is 20.315%. I also incorporate Japan's progressive labor income tax and social insurance systems, including pensions and health insurance, despite their complexity. Agents begin receiving pensions at age sixty with a probability of 0.1372, while others start at age sixty-five. Pension eligibility is determined at age sixty, and the probabilities are independent of all other factors.

For other parameters, I adopt values from existing literature. The capital share of income, α, and the elasticity of substitution between nonlinear and linear occupations, ψ, are set to 0.36 and 0.67, respectively, following Jang and Yum [2022]. For the Frisch elasticity, γ, I use the estimate of 1.50 from Keane [2022] after reviewing several studies on the parameter.

I standardize prices using the mean hourly wage and adjust the total factor productivity of the representative firm so that the model's average hourly wage equals 1.

4.2 Calibration Result

Table 2 summarizes the internally calibrated parameters, computed to match the target moments in the data.

Figure 5 shows the share of workers in each occupation by age. As labor disutility increases independently of occupation, the model predicts a slight decline in the share of nonlinear occupations, while successfully replicating changes in the share of linear occupations. Figure 6 also reflects a similar trend between the data and the model. The presence of κ motivates workers to reduce working hours after age 60, with the decline plateauing around age 70. At this point, workers are motivated to work more than 20 hours per week to maintain or increase pension benefits. Working fewer hours results in slightly lower pension benefits, while full-time work subjects them to the earnings test,explaining the preference for part-time work among older individuals. In Appendix, I compare graphs of wage, labor force participation, and asset holdings from the baseline model with the data.

Table 2: Internally Calibrated Parameters

Parameter			**Target Statistics**			
	Value	Description	Data	Model	Description	Data Source
β	1.0094	Discount Factor	0.0107	0.01082	Real interest rate	International Monetary Fund
μ_ϕ	10.40	Mean of working hours	0.4226	0.4223	$\mathbb{E}[h\|25 \leq t \leq 59]$	JPSED
δ_ϕ	1.900	S.D. of labor disutility	0.2665	0.2273	sd(log(h)) (25-59 years old)	JPSED
κ	0.04850	Coefficient in Φ	44.31	44.9187	LFP rate between 60 and 79	JPSED
ξ	0.3900	Labor Force participation cost	5.6034	5.6090	Proportion of workers with $h < 20$ per week (%)	JPSED
ν	0.5570	Weight of NL laborforce	1.1605	1.1655	$\mathbb{E}[wmh^\theta gzf\|j = NL]/\mathbb{E}[wmh^\theta gzf\|j = L]$	JPSED
σ_{η_1}	0.1600	Variance of η_1	0.8884	0.8950	Share of all workers in NL	JPSED
θ_1	0.4088	Curvature of $g_{NL}(\cdot)$	0.1408	0.1514	Part-time penalty (NL)	JPSED
θ_2	0.2480	Curvature of $g_L(\cdot)$	0.07766	0.07740	Part-time penalty (L)	JPSED
Ω_1	0.02130	Coefficient in $z_N L(\cdot)$	0.3868	0.3931	Experience Premium in NL	JPSED
Ω_2	0.01900	Coefficient in $z_L(\cdot)$	.3018	0.3026	Experience Premium in L	JPSED
π_1	-0.1130	Coefficient in log $f_N L(\cdot)$	0.7564	0.7763	Wage reduction after sixty in NL	JPSED
π_2	-0.06200	Coefficient in log $f_L(\cdot)$	.7922	0.8082	Wage reduction after sixty in L	JPSED
μ_1	-43.00	Concern about leaving bequests	0.01283	0.020216	Inheritance rate	JPSED
μ_2	1.700	Bequests as luxury goods	1.2753	1.1254	30th pct of Assets (80-105 years old)	JHPS/KHPS
ρ	0.3310	Coefficient in ssb(M)	0.1520	0.1519	$\mathbb{E}[ssb(M)]$	Ministry of Health, Labour and Welfare

[1] The efficiency wage of each worker is $\frac{w_j m_j(\eta_1) g_j(h) z_j(x,t) f_j(t)}{h} = w_j m_j(\eta_1) h^{\theta_j} z_j(x,t) f_j(t)$.

[2] Part-time penalty in occupation j is defined by $\mathbb{E}[wmh^\theta zf|j, h \geq \mathcal{F}] - \mathbb{E}[wmh^\theta zf|j = NL, h < \mathcal{F}]$. The difference is used as a measure of part-time penalty instead of ratios because it is a better way to gauge the curvature of the function, $g_j(\cdot)$.

[3] Experience Premium in occupation j is also defined by $\mathbb{E}[wmh^\theta zf|j, 50 \leq t \leq 59] - \mathbb{E}[wmh^\theta zf|j, 25 \leq t \leq 34]$. For the same reason as part-time penalty, I use the difference, not the ratio.

[4] Wage reduction after 60 years old in occupation j denotes $\mathbb{E}[wmh^\theta zf|j = NL, 60 \leq t \leq 69]/\mathbb{E}[wmh^\theta zf|j = NL, 50 \leq t \leq 59]$, which is the ratio of efficiency wage of workers between 60 and 69 years old to that of those between 50 and 59 years old.

[5] LFP rate is an acronym for "Labor force participation rate".

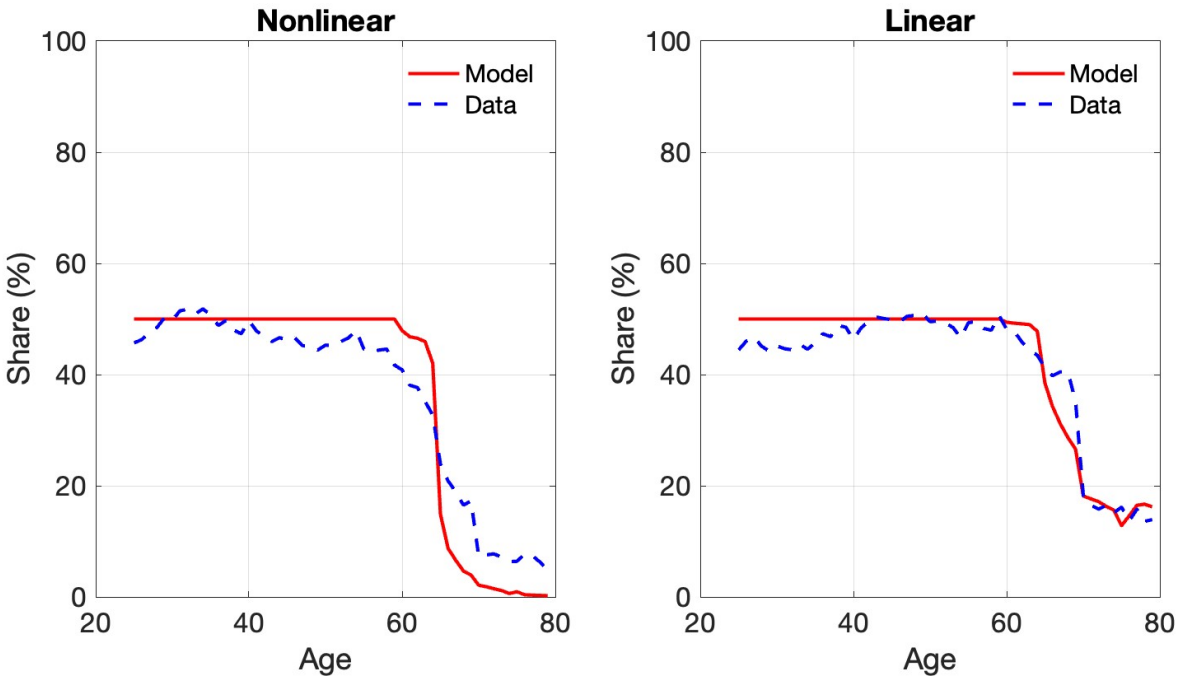


Figure 5: Unconditional Occupation Share (Model vs Data)

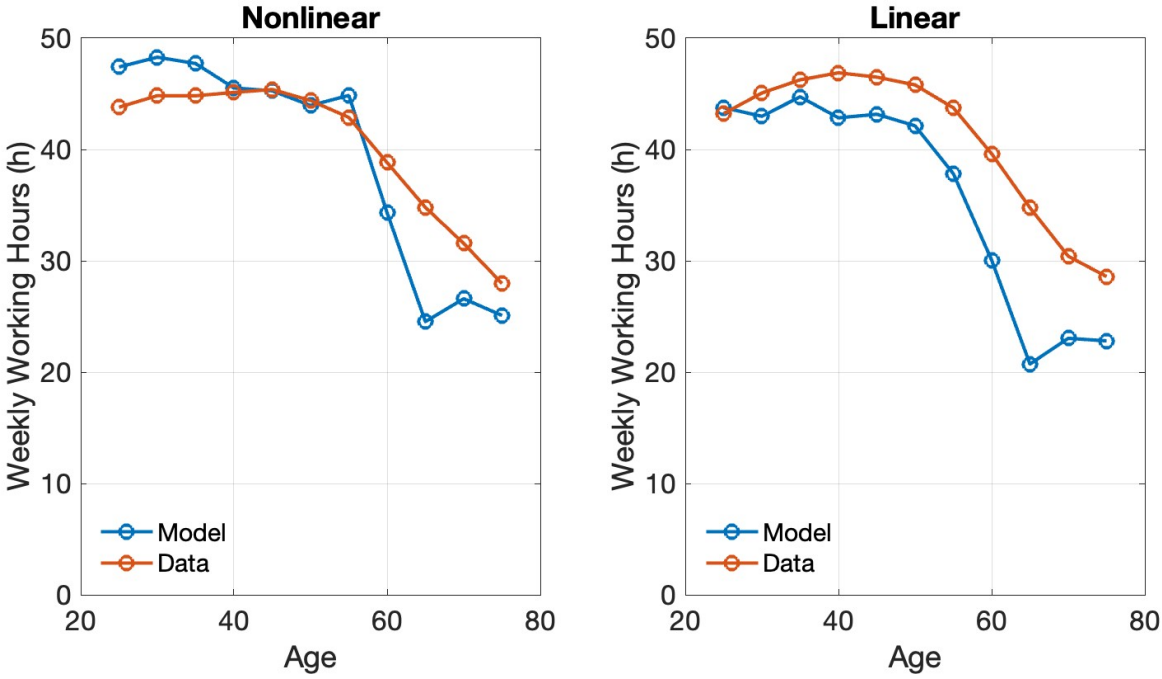


Figure 6: Working Hours per week(Model vs Data)

4.3 Source of nonlinearity

The parameters driving nonlinearity in the model are analyzed, focusing on the part-time penalty, experience premium, and wage reduction after retirement. Nonlinearity is characterized by three indicators: the wage gap between full-time and part-time workers, the wage gap between workers in their fifties and sixties, and the wage ratio between workers in their seventies and sixties.

The analysis reduces the values of θ, Ω, and π by half and examines the outcomes in partial equilibrium (Table 3). A lower θ encourages part-time work, increasing both the extensive and intensive labor margins for older workers, particularly in nonlinear occupations, and boosting capital supply. In contrast, Ω has minimal impact on nonlinearity, while π partially affects the part-time penalty.

Table 3: Source of nonlinearity (Partial equilibrium)[23]

	Baseline	$\theta \downarrow 50\%$	$\Omega \downarrow 50\%$	$\pi \downarrow 50\%$
Supply side				
Δ Labor Supply(NL)(%)		+8.649	-14.61	+1.082
Δ Labor Supply(L)(%)		+7.101	-15.94	+1.604
Δ Labor Supply(Age:60-79)(%)		+61.55	-30.80	+25.13
Δ Capital Supply(%)		-7.034	-10.13	-2.766
Δ Tax Revenue(%)		+5.019	-15.28	0.5190
Labor Market Indicators				
LFP Rate(Age:60-79)(%)	44.9187	77.04	37.09	53.46
Part-time Rate (NL)(%)	10.9677	48.17	13.36	12.65
Part-time Rate (L)(%)	31.6372	57.18	39.01	34.56
Average Working Hours(Age:25-79)	0.4223	0.3806	0.4192	0.4177
NL/L: Population ratio	0.8950	0.9681	0.8901	0.9035
NL/L: Wage ratio	1.1655	1.184	1.1605	1.1591
Part-time penalty (NL)	0.1514	0.03233	0.1314	0.09217
Part-time penalty (L)	0.07740	0.01602	0.05307	0.05151
Experience Premium (NL)	0.3931	0.4790	0.09224	0.3822
Experience Premium (L)	0.3026	0.3525	0.1028	0.3036
Wage reduction after 60(NL)	0.7763	0.7812	0.7946	0.8527
Wage reduction after 60(L)	0.8082	0.8480	0.8168	0.8561

5 Counterfactual Experiment

Several counterfactual experiments are conducted to evaluate both conventional and unconventional policy reforms. Although conventional policies are likely to reduce welfare, unconventional policies, including income tax reforms, increase welfare, while increasing output.

[23]NL/L:Population ratio is the ratio of the number of Nonlinear workers to that of Linear workers. Also, NL/L:Wage ratio means the ratio of the average efficiency wage of Nonlinear workers to that of Linear workers.

Note that in all the experiments, the real interest rate is about 1% , while there is no population growth and no technological growth in the stationary equilibria: the equilibria are dynamically efficient.

First, as shown in Table 4, eliminating the earnings test positively impacts consumption equivalence: the short-term consumption equivalence (CEV) [24] and long-term CEV at 25 years old are 0.001061% and 0.01940%, respectively. Across all generations, the short-term CEV remains positive but small, as shown in Figure 7. This reform does not affect the extensive margin of older individuals but increases the intensive margin by 2.539%. Additionally, it boosts aggregate output, labor supply, capital supply, and tax revenue, though these increases remain under 1%.

Second, extending the pension eligibility age by five years delays benefits from age 60 to 65 and from 65 to 70. This reform reduces welfare, particularly for those approaching retirement. While it increases labor supply among older workers in both nonlinear and linear occupations, it reduces capital supply and output. The expanded labor supply also causes younger and middle-aged individuals to work less, leading to wage declines that lower earnings and discourage savings in anticipation of extended working years, as shown in Appendix. This result arises from capital adjustments driven by price changes and the intertemporal substitution of labor, as workers anticipate longer working lives. When comparing factors, these forces significantly contribute to the observed changes, whereas competition between younger and older individuals for labor supply has only a slight effect. Although Imrohoroğlu and Kitao [2012] demonstrates that extending the normal retirement age increases capital as individuals save to smooth consumption during periods without pension eligibility, this model allows workers to adjust their extensive margin to maintain consumption levels, which consequently reduces the capital supply.

Third, reducing employees' pension benefits by half, resulting in a 28.66% average decrease in pension benefits, lowers welfare in both the short and long term. Output declines by 0.0703%, and the increased labor supply from older individuals suppresses wages, discouraging labor supply and earnings for the working-age population. Workers in linear occupations, earning lower wages and holding fewer assets, experience a stronger income effect, increasing their labor supply in linear

[24] The short-term CEV refers to the consumption equivalent variation for individuals aged 25 immediately following the policy reform, based on the distribution of agents in the baseline model. In contrast, the long-term CEV represents the consumption equivalent variation for individuals of the same age between the two stationary equilibria

For example, CEV at age t, denoted as CEV_t, is defined as follows: Let $\{c_s^0, h_s^0, a_{s+1}^0\}_{s=t}^T$ and $\{c_s^1, h_s^1, a_{s+1}^1\}_{s=t}^T$ represent the household's allocation in an equilibrium of the baseline model and the compared allocation, respectively.

$$u\Big((1+CEV_t)c_t^0, h_t^0\Big) + \Big(1-S(t)\Big)\mu(a_{t+1}^0) + \sum_{s=t+1}^{T} \beta^{s-t} S(s-1)\Big\{u\Big((1+CEV_t)c_s^0, h_s^0\Big) + \Big(1-S(s)\Big)\mu(a_{s+1}^0)\Big\}$$
$$= u\Big(c_t^1, h_t^1\Big) + \Big(1-S(t)\Big)\mu(a_{t+1}^1) + \sum_{s=t+1}^{T} \beta^{s-t} S(s-1)\Big\{u\Big(c_s^1, h_s^1\Big) + \Big(1-S(s)\Big)\mu(a_{s+1}^1)\Big\}$$

occupations more than in nonlinear ones.

Next, I examine the effects of unconventional policy reforms on welfare, output, and labor. Reducing θ_{NL} to the same level as θ_L boosts older individuals' labor supply by 19.47% and raises the LFP rate for those in their 60s and 70s by 10.64%. This increase in nonlinear labor supply also enhances capital supply and output, yielding a long-term CEV of 0.8773%.

Moreover, I cut π_1 and π_2 by half, corresponding to the age-penalty in nonlinear and linear occupations, respectively. This experiment increases labor supply, capital supply, and output but results in a small negative CEV due to the extended working years required.

Furthermore, enhancing tax credits by 1.5 times, including deductions like the basic and dependents' deductions, lowers the marginal tax rate for workers. This reform boosts older workers' labor participation by 5.35% and increases hourly wages, encouraging continued employment. While tax revenue declines by 2.701%, the labor force expands across occupations, driving savings and increasing output by 2.207%.

Lastly, exempting pensions from income tax increases disposable income, boosting labor supply by 8.958% and raising the labor force participation rate by 6.92%. This reform enhances welfare and increases output by 0.7708%.

These experiments show that conventional policies like extending pension eligibility and cutting benefits reduce welfare (CEV) and face resistance from middle-aged and older individuals, delaying implementation. In contrast, unconventional policies boost welfare and encourage increased labor supply, including greater participation in nonlinear occupations.

Table 4: Conventional Policies [25]

	Baseline	Eliminate ETest	Extend Pen Age by five years	Lower Pension	$\theta_{NL} \downarrow$ until θ_L	$\pi \downarrow$ until 0.5 π	Increase Tax Credit	No Tax on Pension
Consumption Equivalence								
Short term CEV(Age:25)(%)		+0.001061	-4.152	-1.880	-0.008137	-0.004552	+2.062	+0.2610
Long term CEV(Age:25)(%)		+0.01940	-0.05688	-4.441	+0.8773	-0.09088	+ 0.896	+ 0.9529
Aggregate Change								
ΔOutput(%)		+0.3556	-0.0811	-0.0703	+2.247	+0.5620	+2.207	+0.7708
Δ Labor Supply(NL)(%)		+0.04820	+1.400	-1.1090	+5.504	+0.1957	+1.763	+0.4959
Δ Labor Supply(L)(%)		+0.03589	+1.023	+ 1.069	-0.4785	+0.9715	+1.785	+0.9071
Δ Labor Supply(Age:60-79)(%)		+2.539	+68.96	+48.92	+19.47	+9.324	+6.010	+8.958
Δ Capital Supply(%)		+0.6505	-2.366	+0.02090	+1.442	+0.5843	+2.982	+0.9258
Δ Tax Revenue(%)		+0.1932	-1.256	-4.241	+1.574	+1.574	-2.701	-0.1220
Labor Market Indicators								
Real interest rate (%)	1.082	1.082	1.201	1.091	1.185	1.091	1.020	1.081
LFP Rate(Age:60-79)(%)	44.92	44.78	62.55	79.63	55.56	48.33	49.27	51.84
Part-time Rate (NL)(%)	10.97	9.800	24.24	31.17	41.69	10.40	11.98	11.89
Part-time Rate (L)(%)	31.64	31.25	39.10	50.23	32.11	33.56	34.69	35.93
AVG Working Hours(Age:25-79)	0.4223	0.4225	0.4009	0.4029	0.4039	0.4213	0.4258	0.4218
NL/L: Population ratio	0.8950	0.8929	0.9314	0.8992	1.018	0.8924	0.8718	0.8811
NL/L: Wage ratio	1.1655	1.166	1.152	1.154	1.198	1.164	1.167	1.165
Part-time penalty (NL)	0.1514	0.1303	0.02576	0.1457	0.03690	0.1231	0.1531	0.1501
Part-time penalty (L)	0.07740	0.07689	0.04881	0.06888	0.07138	0.06779	0.08553	0.08731
Experience Premium (NL)	0.3931	0.3785	0.3552	0.3746	0.4262	0.3734	0.4025	0.3791
Experience Premium (L)	0.3026	0.3050	0.2878	0.2942	0.3043	0.3007	0.3128	0.3010
Wage reduction after 60(NL)	0.7673	0.7960	0.9192	0.7212	0.7787	.8121	0.7645	0.7668
Wage reduction after 60(L)	0.8082	0.8095	0.9094	0.8057	0.8173	0.8258	0.7988	0.8003

[1] Apart from the short-term CEV, all indicators reflect either the changes in the stationary equilibrium relative to the baseline model or the levels within the stationary equilibrium achieved in the experiment.

[2] "Eliminate ETest" denotes eliminating earnings test.

[3] "Extend Pend Age by five years" means extending pension eligibility age by five years.

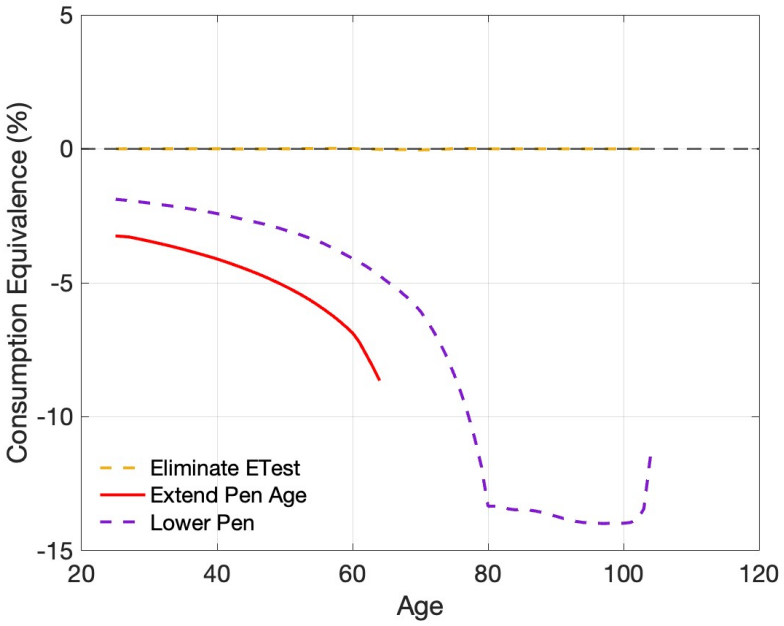


Figure 7: Short-term CEV by Age(Conventional Policies)[26]

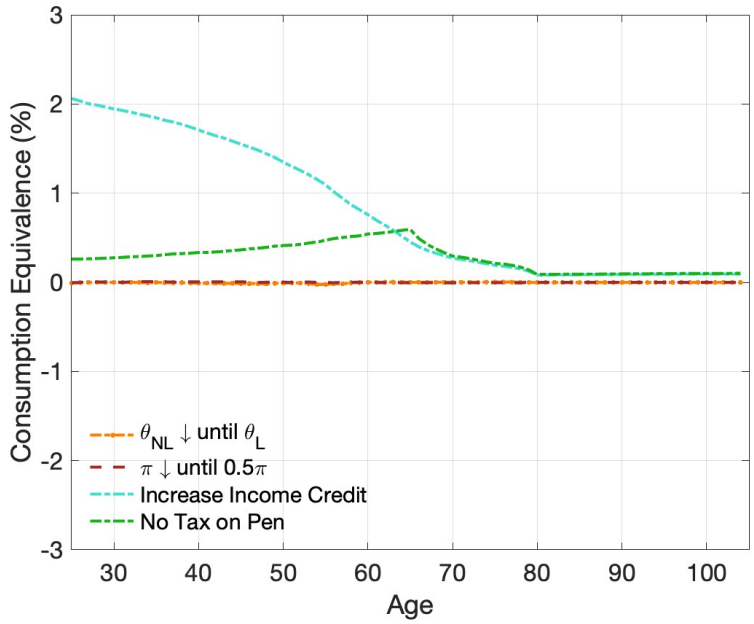


Figure 8: Short-term CEV by Age(Unconventional Policies)

[26]The CEV for the 'Extend Pension Age' policy is plotted only up to age 64 because individuals aged 65 to 69 lose pension eligibility under this reform, which is embedded within the value functions.

6 Conclusion

This study reveals that workers in nonlinear occupations tend to retire earlier than those in linear occupations, based on analyses using JPSED and JHPS/KHPS data. This disparity arises from the high part-time penalties in nonlinear occupations, further magnified by the presence of pensions and assets, which elevate the reservation wage for workers in these occupations.

It also demonstrates that while reducing pension benefits decreases labor supply in nonlinear occupations, other policies effectively increase both the intensive and extensive margins of older workers. These heterogeneous effects arise from the interplay of income and substitution effects across different occupational types. When making policy plans, it is important to consider these heterogeneous effects.

For future research, it is essential to investigate additional factors influencing age-friendliness across occupations, such as working conditions, physical strain, and firms' profit-maximizing strategies. A more comprehensive assessment of these aspects could guide the creation of more effective and targeted policies.

Moreover, examining the labor supply of older females has become increasingly important. While 43.72% of females aged 25–59 are employed part-time, their labor force participation rate remains at approximately 80% within the working-age population. As female workers continue to constitute a growing share of the labor market and approach retirement, understanding their retirement behavior alongside that of males is essential for developing inclusive and comprehensive labor market policies.

References

D. Aaronson and E. French. The effect of part-time work on wages: Evidence from the social security rules. *Journal of Labor Economics*, 22(2):329–352, 2004. URL https://EconPapers.repec.org/RePEc:ucp:jlabec:v:22:y:2004:i:2:p:329-352.

D. Acemoglu, N. S. Mühlbach, and A. J. Scott. The rise of age-friendly jobs. *The Journal of the Economics of Ageing*, 23:100416, 2022.

J. Ameriks, J. Briggs, A. Caplin, M. Lee, M. D. Shapiro, and C. Tonetti. Older americans would work longer if jobs were flexible. *American Economic Journal: Macroeconomics*, 12 (1):174–209, January 2020. doi: 10.1257/mac.20170403. URL https://www.aeaweb.org/articles?id=10.1257/mac.20170403.

P. M. Anderson, A. L. Gustman, and T. L. Steinmeier. Trends in Male Labor Force Participation and Retirement: Some Evidence on the Role of Pensions and Social Security in the 1970s and

1980s. *Journal of Labor Economics*, 17(4):757–783, October 1999. doi: 10.1086/209938. URL https://ideas.repec.org/a/ucp/jlabec/v17y1999i4p757-83.html.

K. Atalay and G. F. Barrett. The impact of age pension eligibility age on retirement and program dependence: Evidence from an australian experiment. *Review of Economics and Statistics*, 97 (1):71–87, 2015.

M. Baker and D. Benjamin. How do retirement tests affect the labour supply of older men? *Journal of Public Economics*, 71(1):27–51, 1999.

G. Becker. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education, Second Edition*. National Bureau of Economic Research, Inc, 1975. URL https://EconPapers.repec.org/RePEc:nbr:nberbk:beck75-1.

M. Bertrand, C. Goldin, and L. F. Katz. Dynamics of the gender gap for young professionals in the financial and corporate sectors. *American economic journal: applied economics*, 2(3):228–255, 2010.

D. M. Blau and R. M. Goodstein. Can social security explain trends in labor force participation of older men in the united states? *Journal of human Resources*, 45(2):328–363, 2010.

A. S. Blinder, R. H. Gordon, and D. E. Wise. Reconsidering the work disincentive effects of social security. *National tax journal*, 33(4):431–442, 1980.

R. Blundell and C. Emmerson. Fiscal effects of reforming the uk state pension system. *Institute for Fiscal Studies Working Paper, WP03/13*, 2003.

R. Blundell, E. French, and G. Tetlow. Retirement incentives and labor supply. pages 457–566, 2016. URL https://EconPapers.repec.org/RePEc:eee:hapoch:v1_457.

K. M. Brown. The link between pensions and retirement timing: Lessons from california teachers. *Journal of Public Economics*, 98:1–14, 2013.

J. Cribb, C. Emmerson, and G. Tetlow. Incentives, shocks or signals: labour supply effects of increasing the female state pension age in the uk. Technical report, IFS working papers, 2013.

M. De Nardi. Wealth inequality and intergenerational links. *Review of Economic Studies*, 71 (3):743–768, 2004. URL https://EconPapers.repec.org/RePEc:oup:restud:v:71:y:2004:i:3:p:743-768.

R. Disney and S. Smith. The labour supply effect of the abolition of the earnings rule for older workers in the united kingdom. *The Economic Journal*, 112(478):C136–C152, 2002.

A. Erosa, L. Fuster, G. Kambourov, and R. Rogerson. Hours, occupations, and gender differences in labor market outcomes. *American Economic Journal: Macroeconomics*, 14(3):543–590, 2022.

X. Fan, A. Seshadri, and C. R. Taber. Estimation of a Life-Cycle Model with Human Capital, Labor Supply and Retirement. NBER Working Papers 29905, National Bureau of Economic Research, Inc, Apr. 2022. URL https://ideas.repec.org/p/nbr/nberwo/29905.html.

E. French. The Effects of Health, Wealth, and Wages on Labour Supply and Retirement Behaviour. *Review of Economic Studies*, 72(2):395–427, 2005. URL https://ideas.repec.org/a/oup/restud/v72y2005i2p395-427.html.

E. French and J. Jones. Public pensions and labor supply over the life cycle. *International Tax and Public Finance*, 19(2):268–287, April 2012. doi: 10.1007/s10797-011-9184-x. URL https://ideas.repec.org/a/kap/itaxpf/v19y2012i2p268-287.html.

L. Friedberg. The labor supply effects of the social security earnings test. *Review of Economics and Statistics*, 82(1):48–63, 2000.

A. M. Gelber, D. Jones, and D. W. Sacks. Earnings adjustment frictions: Evidence from the social security earnings test. 2013.

D. Gicheva. Working long hours and early career outcomes in the high-end labor market. *Journal of Labor Economics*, 31(4):785–824, 2013.

C. Goldin. A grand gender convergence: Its last chapter. *American economic review*, 104(4): 1091–1119, 2014.

A. L. Gustman and T. Steinmeier. How changes in social security affect recent retirement trends. *Research on Aging*, 31(2):261–290, 2009.

S. J. Haider and D. S. Loughran. Elderly labor supply. *Workplace flexibility: Realigning 20th-century jobs for a 21st-century workforce*, page 110, 2010.

B. Hanel and R. T. Riphahn. The timing of retirement—new evidence from swiss female workers. *Labour economics*, 19(5):718–728, 2012.

S. Imrohoroğlu and S. Kitao. Social security reforms: Benefit claiming, labor force participation, and long-run sustainability. *American Economic Journal: Macroeconomics*, 4(3):96–127, 2012.

International Monetary Fund. International financial statistics and data files using world bank data on the gdp deflator. URL https://databank.worldbank.org/reports.aspx?source=2&type=metadata&series=FR.INR.RINR. Accessed from IMF database.

Y. Jang and M. Yum. Nonlinear occupations and female labor supply over time. *Review of Economic Dynamics*, 46:51–73, 2022.

R. W. Johnson and D. Neumark. Wage declines among older men. *The Review of Economics and Statistics*, pages 740–748, 1996.

M. P. Keane. Recent research on labor supply: Implications for tax and transfer policy. *Labour Economics*, 77:102026, 2022.

R. Lalive and S. Staubli. How does raising women's full retirement age affect labor supply, income, and mortality. *NBER working paper*, 18660:17, 2015.

G. Mastrobuoni. Labor supply effects of the recent social security benefit cuts: Empirical estimates using cohort discontinuities. *Journal of public Economics*, 93(11-12):1224–1233, 2009.

J. Mincer. Schooling, experience, and earnings. human behavior & social institutions no. 2. 1974.

OECD. Demographic old-age to working-age ratio. *Pensions at a Glance 2023: OECD and G20 Indicators*, pages 184–185, 2023.

J. F. Pingle. Social security's delayed retirement credit and the labor supply of older men. 2006.

R. Rogerson and J. Wallenius. Nonconvexities, retirement, and the elasticity of labor supply. *American Economic Review*, 103(4):1445–1462, 2013.

S. Shimizutani. Social security earnings test and the labour supply of the elderly: New evidence from unique survey responses in japan. *The Japanese Economic Review*, 64:399–413, 2013.

S. Shimizutani, T. Oshio, et al. *The Labor Supply Effect of Social Security Earnings Test Revisited: New Evidence from its Elimination and Revival in Japan*. Institute of Economic Research, Hitotsubashi University, 2008.

J. G. Song and J. Manchester. New evidence on earnings and benefit claims following changes in the retirement earnings test in 2000. *Journal of Public Economics*, 91(3-4):669–700, 2007.

S. Staubli and J. Zweimüller. Does raising the early retirement age increase employment of older workers? *Journal of public economics*, 108:17–32, 2013.

The data for this secondary analysis, "Japanese Panel Study of Employment Dynamics(2016-2023)[27], Recruit Works Institute," was provided by the Social Science Japan Data Archive, Center for Social Research and Data Archives, Institute of Social Science, The University of Tokyo.

[27]This questionnaire is conducted every January and it asks people about the last year. Thus, I regard the data of a certain year as the information of the previous year.

The data for this analysis, Japan Household Panel Survey (JHPS/KHPS), was provided by the Panel Data Research Center, Institute for Economic Studies, Keio University.

Appendix

A.1. Calibration result

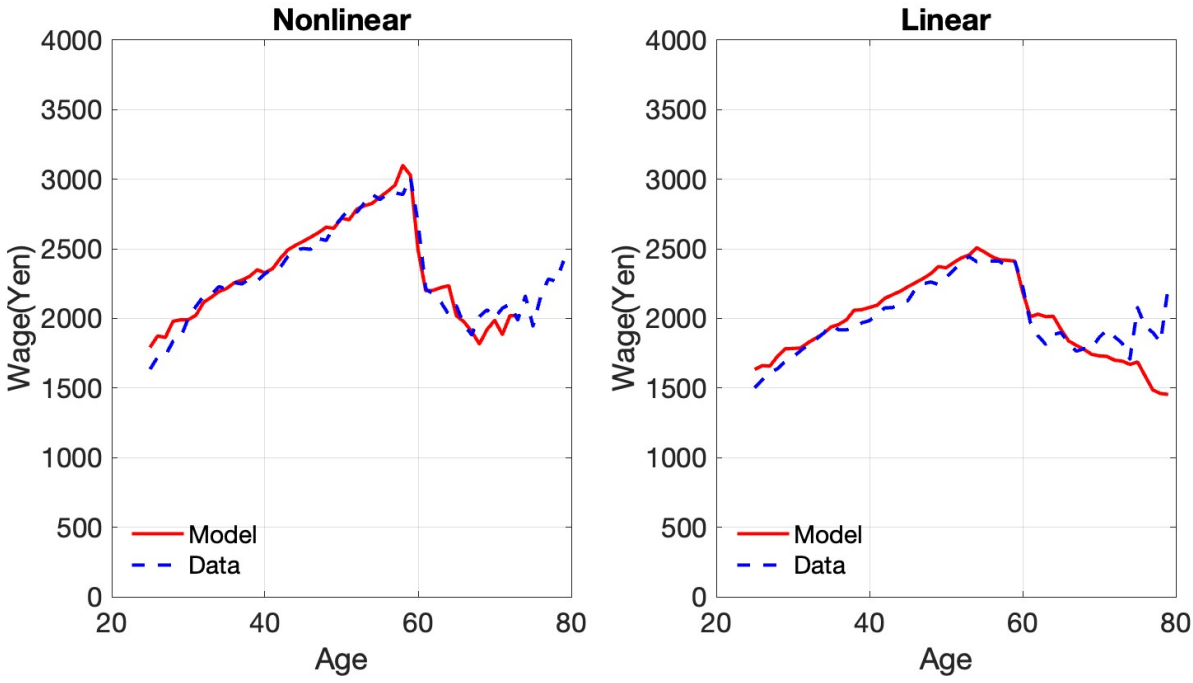


Figure 9: Wage difference (Model vs Data)

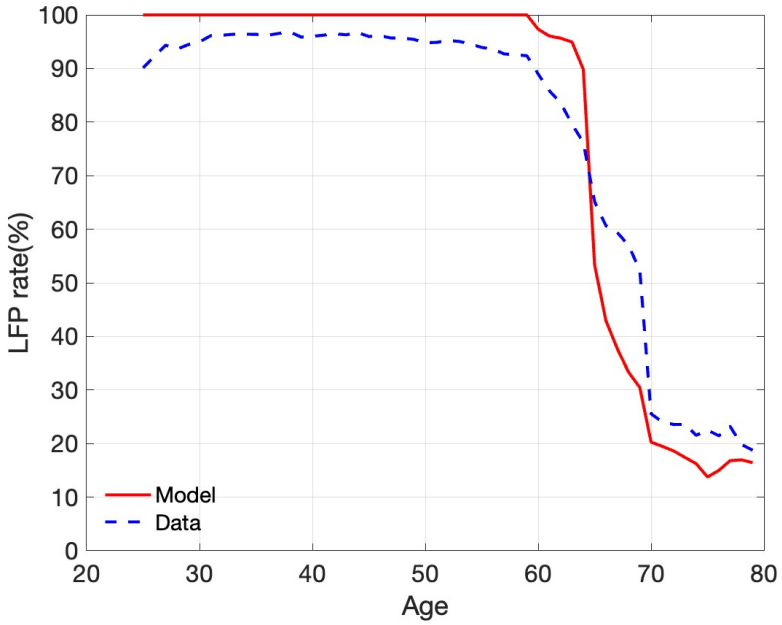


Figure 10: LFP rate (Model vs Data)

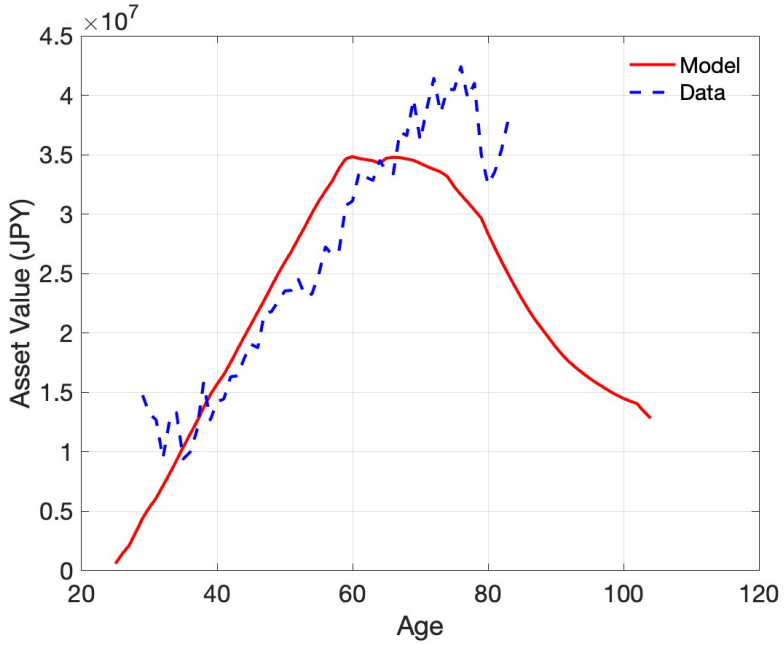


Figure 11: Asset (Model vs Data)

A.2. Source of nonlinearity

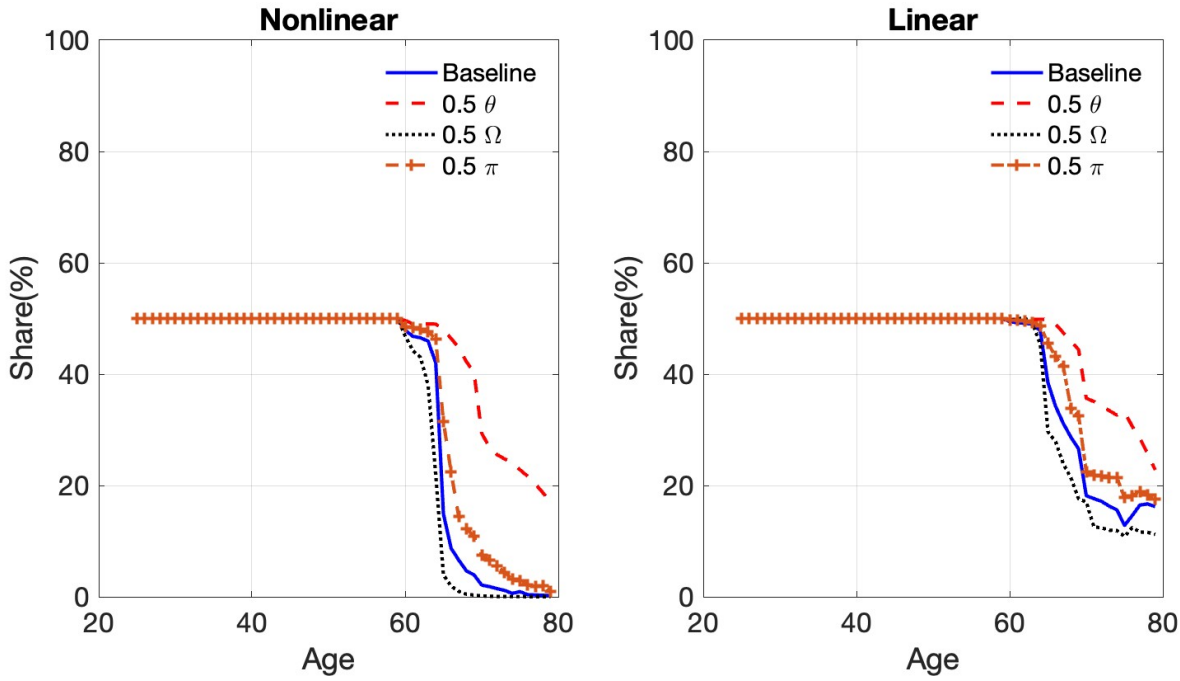


Figure 12: Unconditional Occupation Share (Source of nonlinearity)

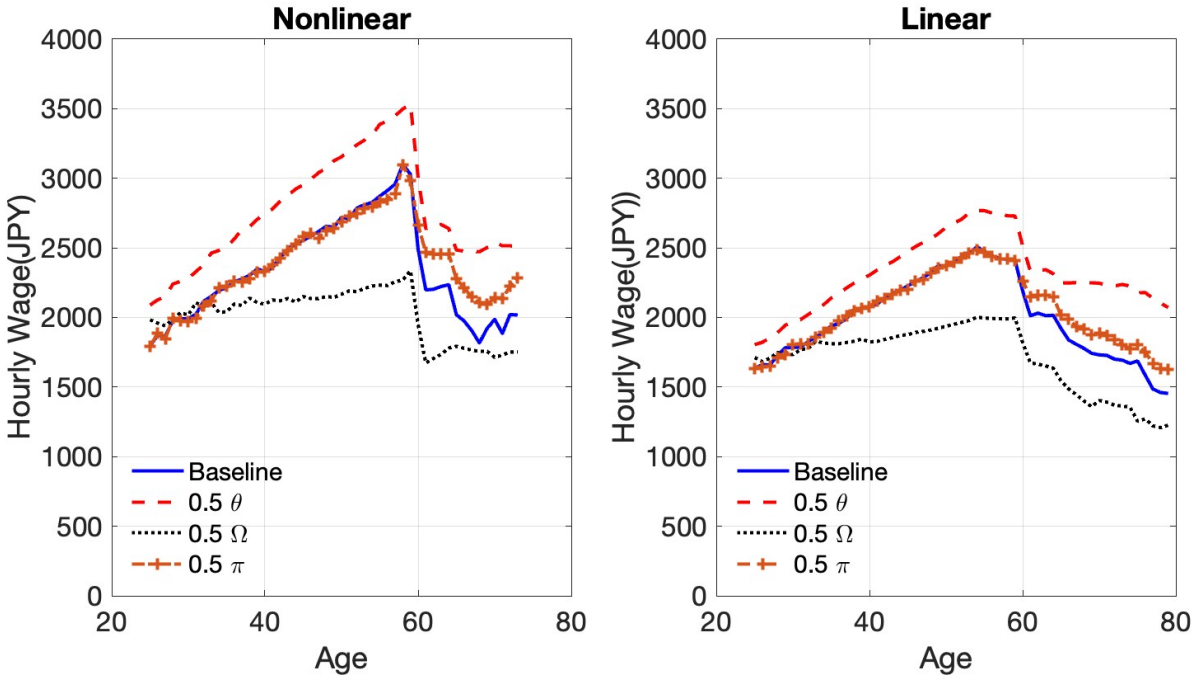


Figure 13: Wage difference (Source of nonlinearity)

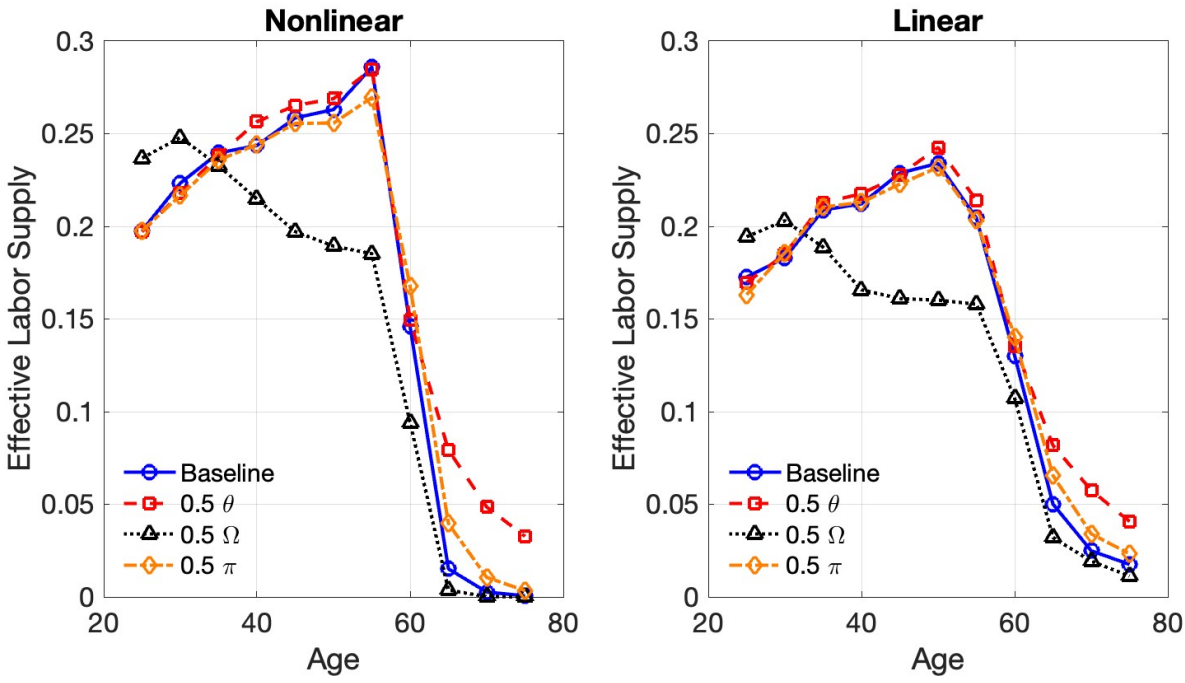


Figure 14: Effective Labor Supply (Source of nonlinearity)

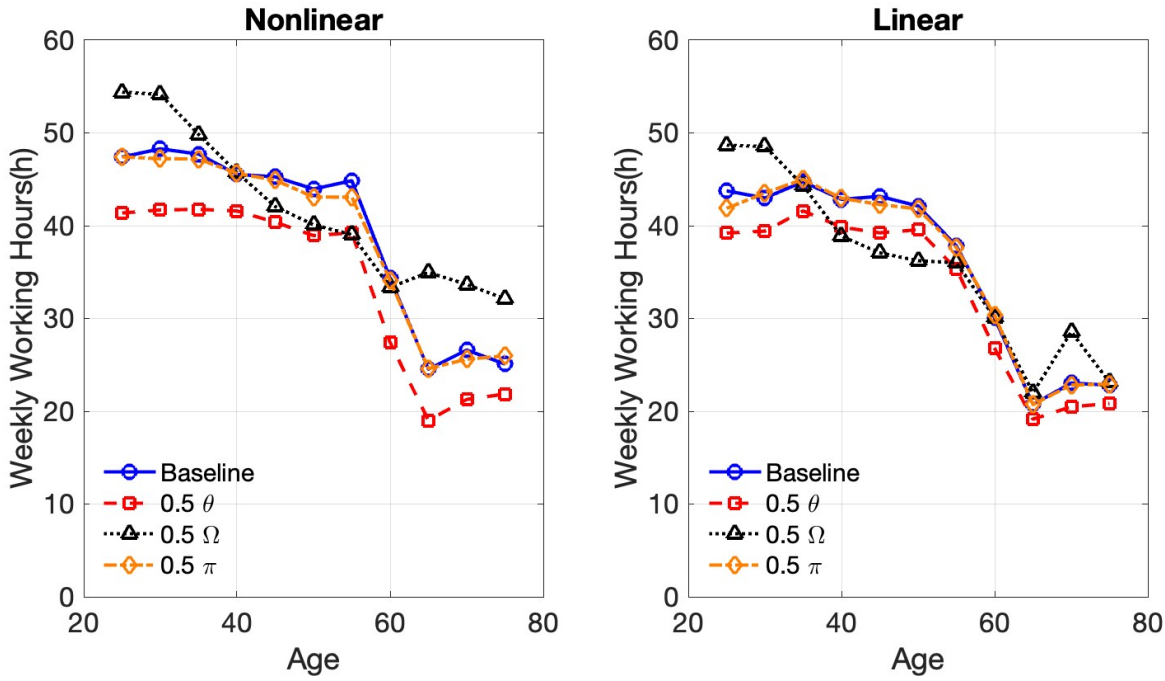


Figure 15: Working Hours per week (Source of nonlinearity)

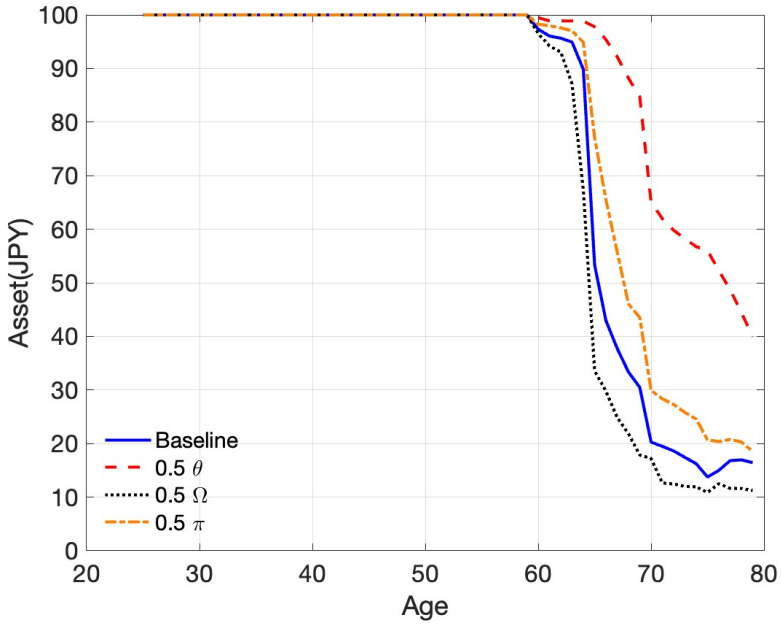


Figure 16: LFP (Source of nonlinearity)

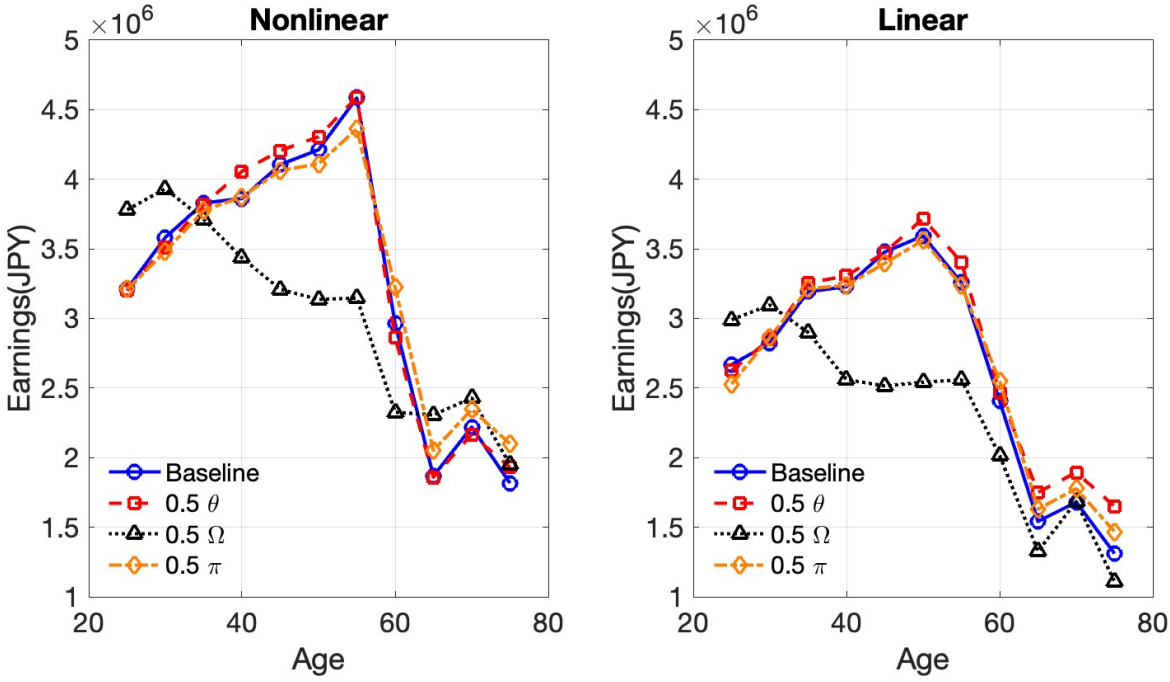


Figure 17: Earnings (Source of nonlinearity)

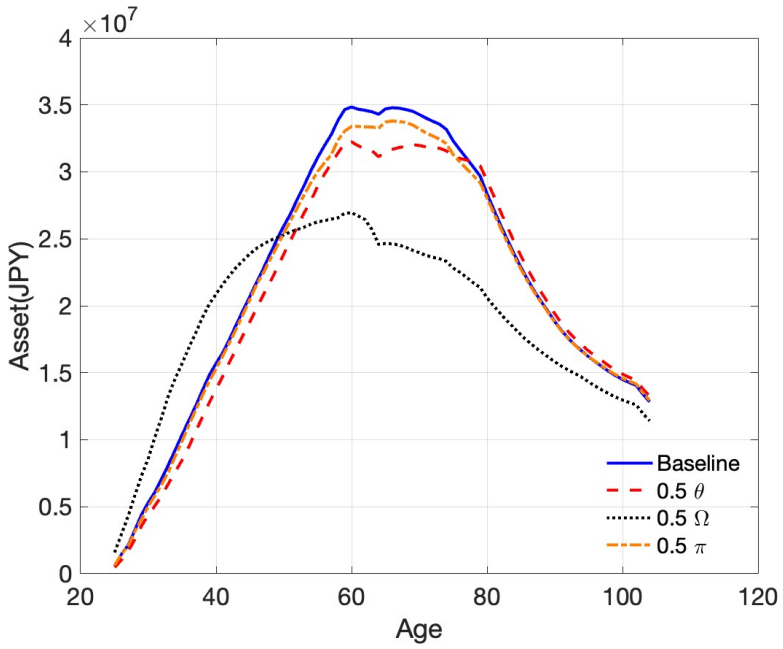


Figure 18: Asset (Source of nonlinearity)

A.3. Counterfactual Experiment(Conventional Policy)

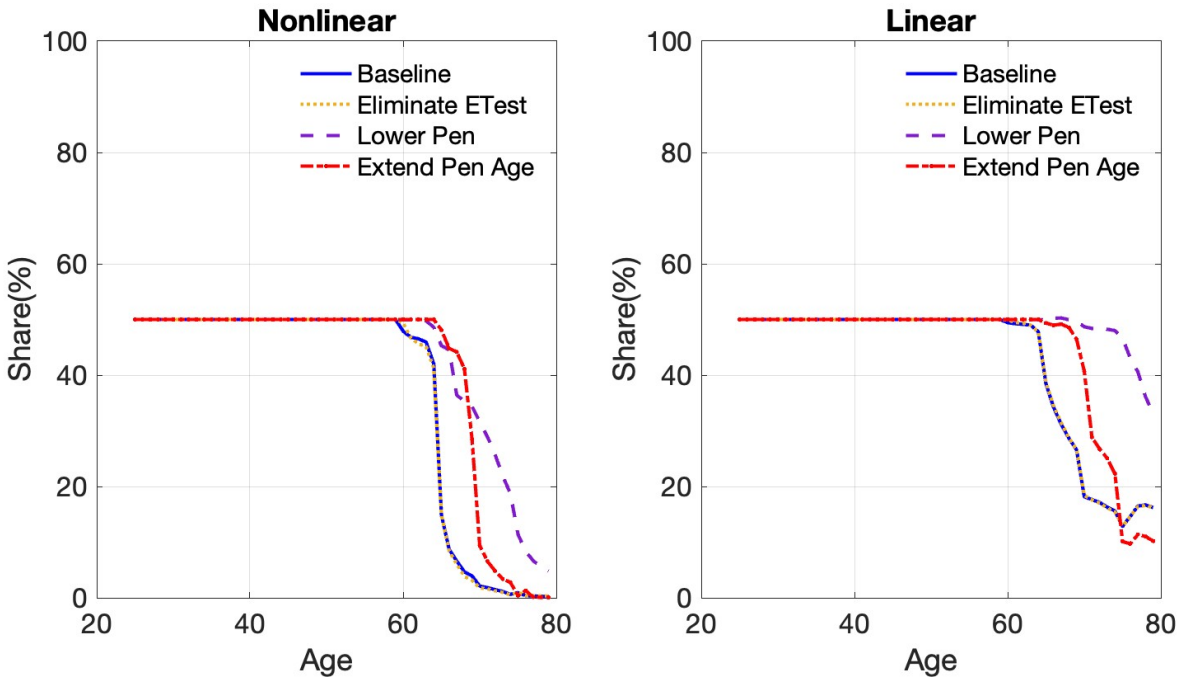


Figure 19: Unconditional Occupation Share(Conventional Policy)

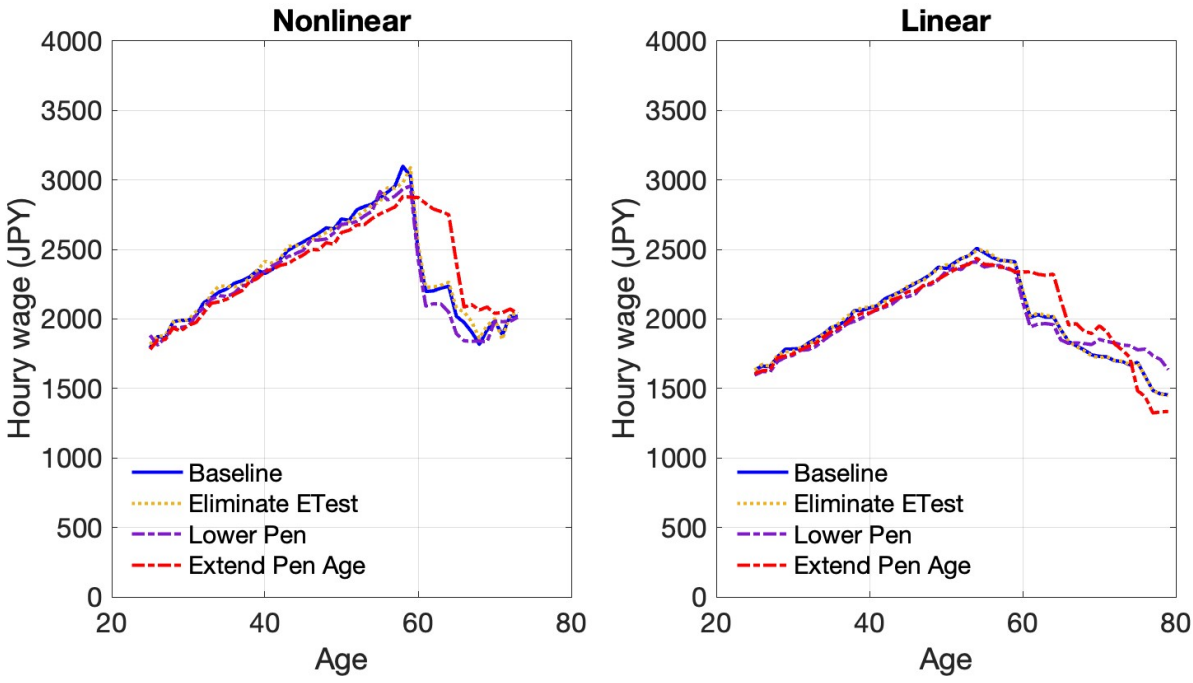


Figure 20: Wage difference (Conventional Policy)

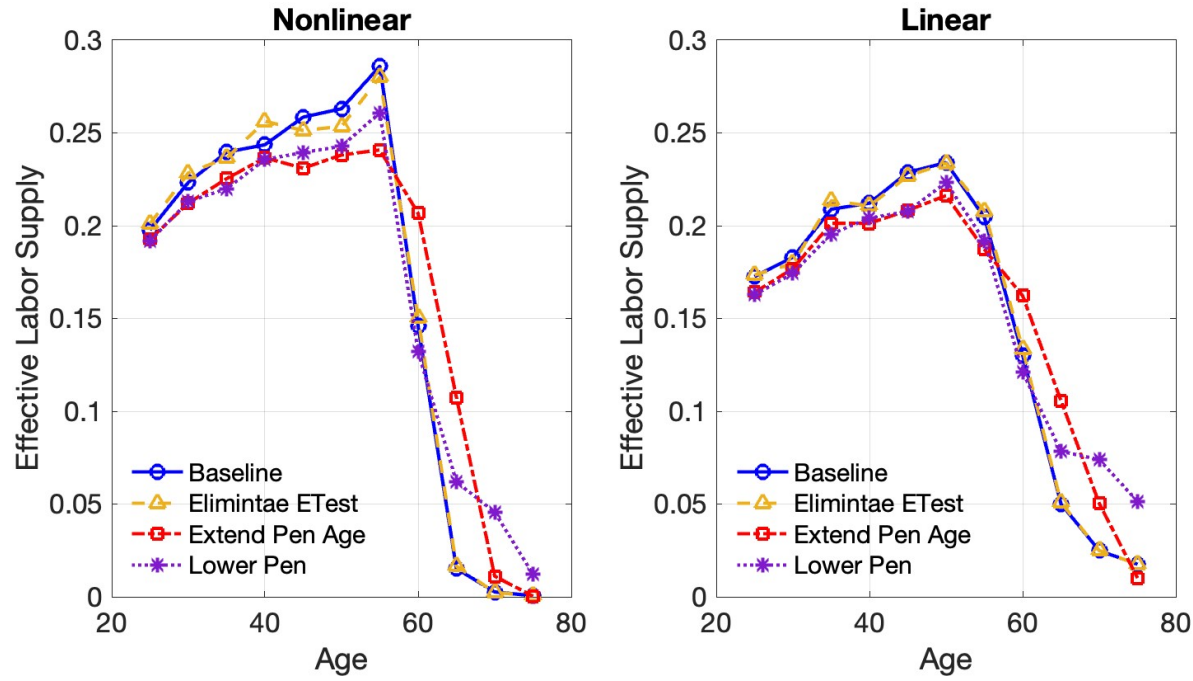


Figure 21: Effective Labor Supply(Conventional Policies)

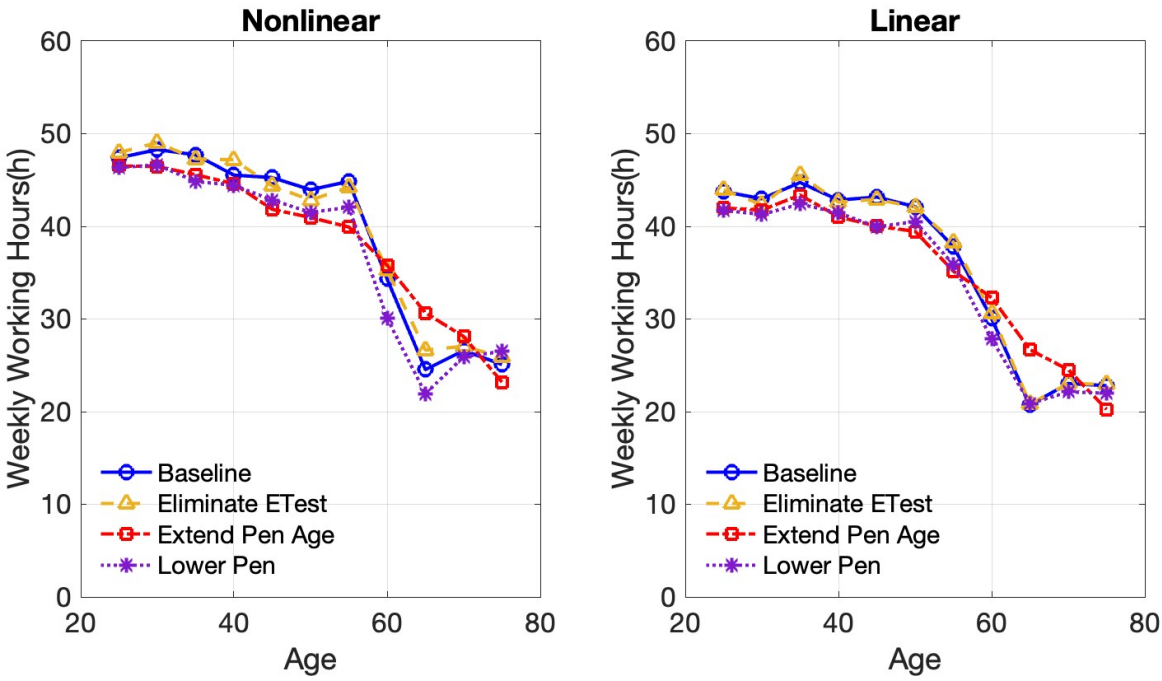


Figure 22: Weekly Working Hours (Conventional Policy)

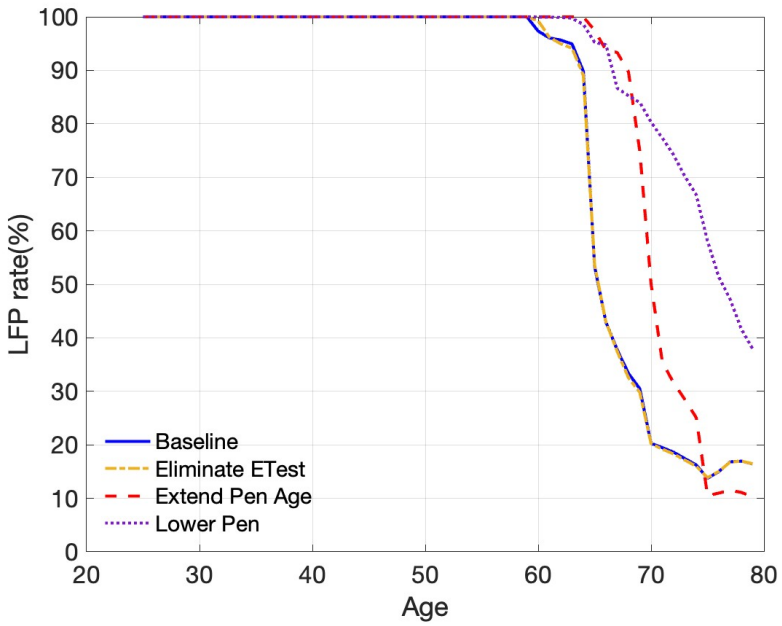


Figure 23: LFP rate (Conventional Policy)

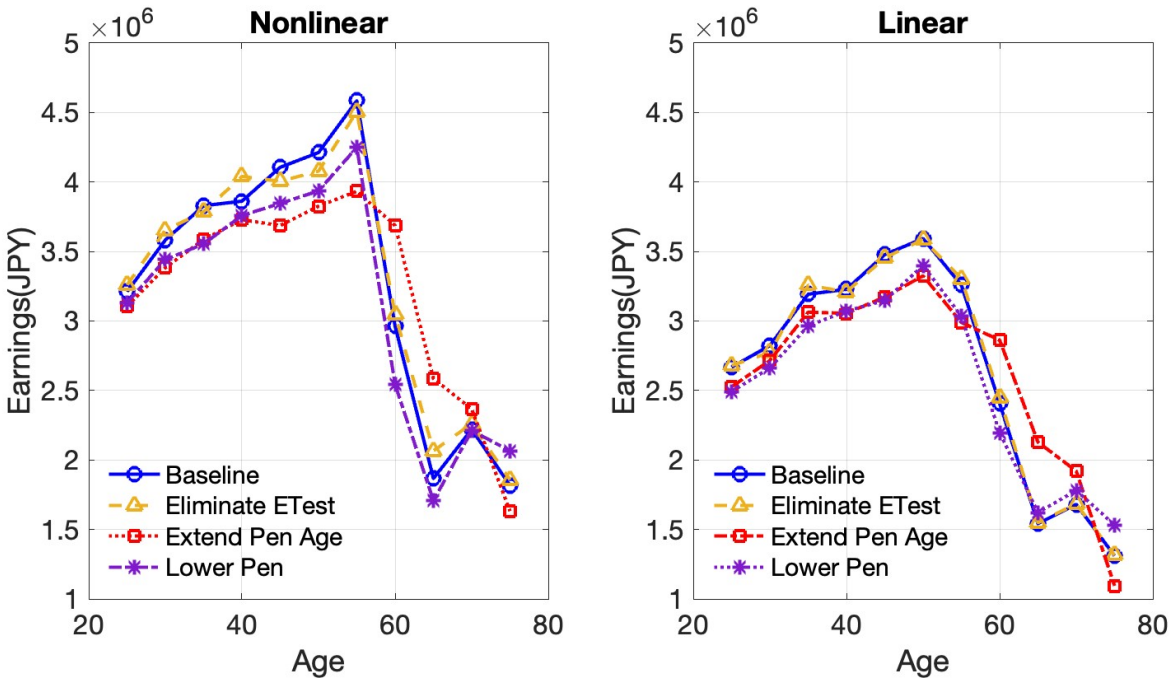


Figure 24: Earnings (Conventional Policy)

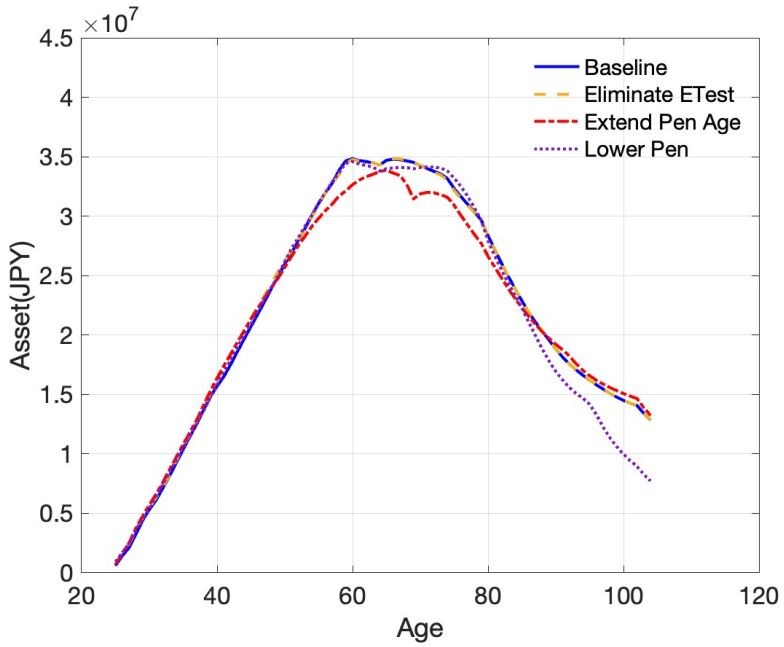


Figure 25: Asset (Conventional Policy)

A.4. Counterfactual Experiment(Unconventional Policy)

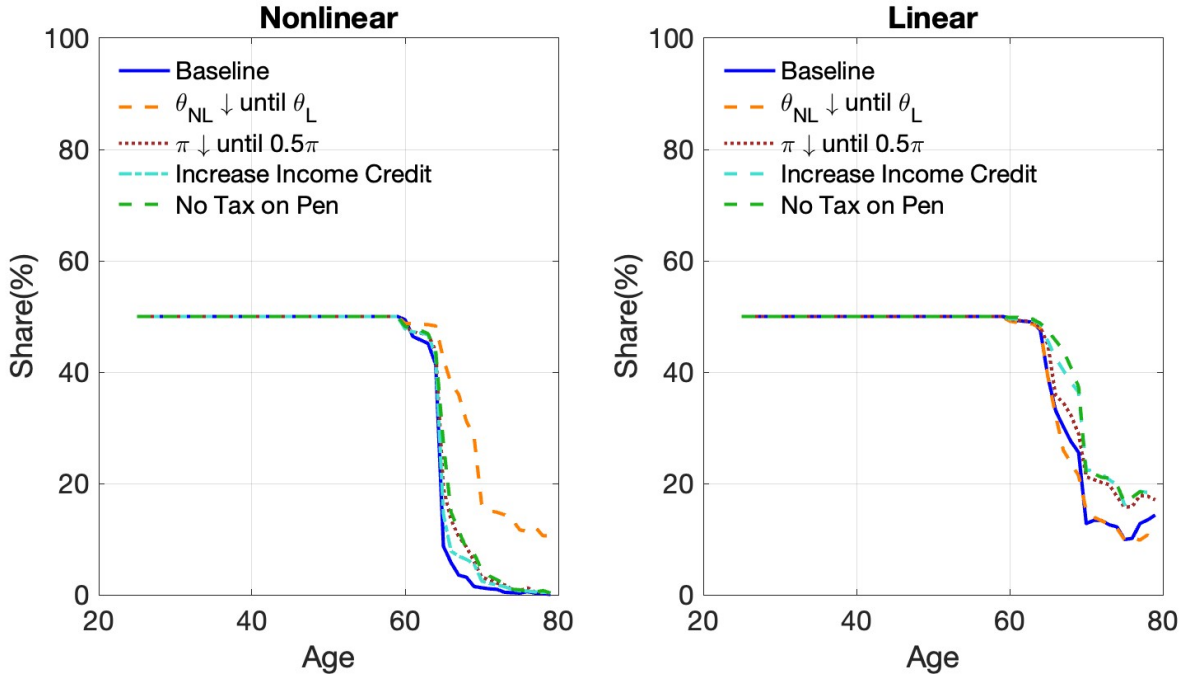


Figure 26: Unconditional Occupation Share (Unconventional Policy)

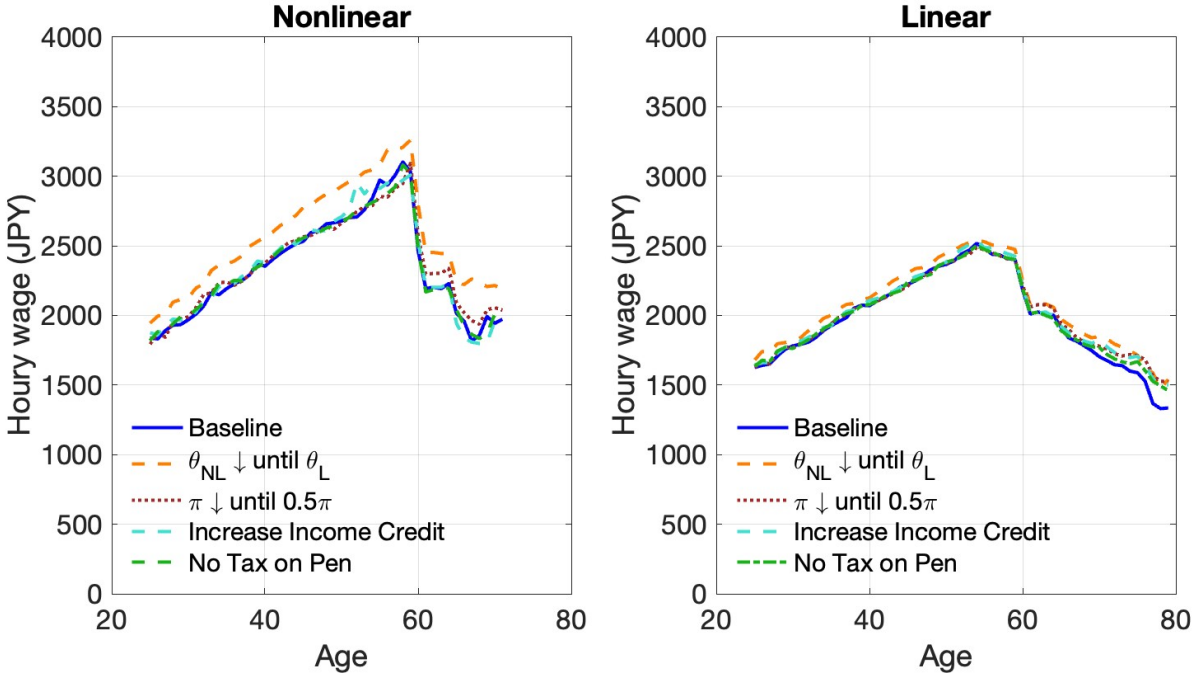


Figure 27: Wage difference (Unconventional Policy)[28]

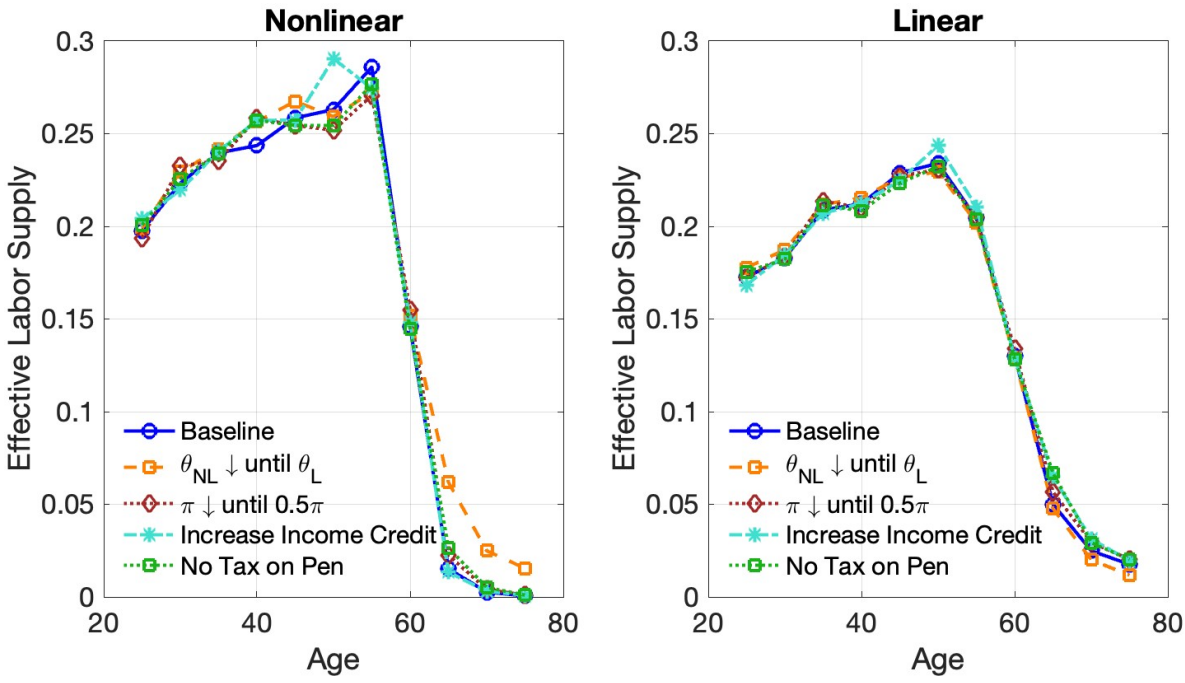


Figure 28: Effective Labor Supply(Unconventional Policy)

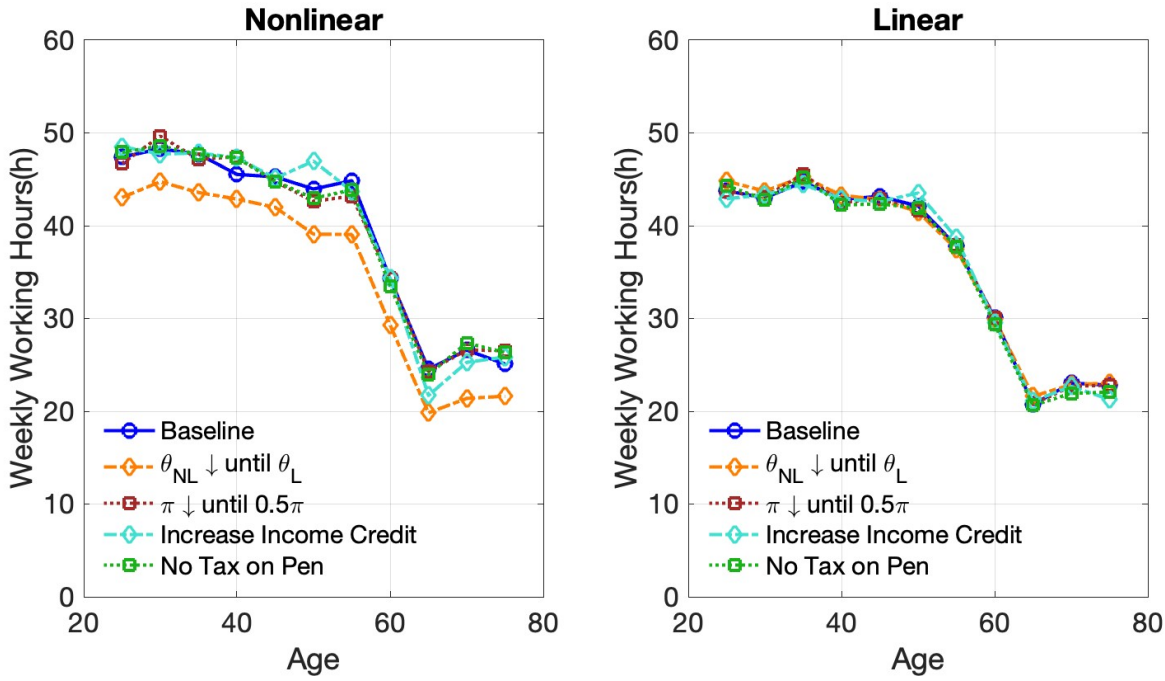


Figure 29: Working Hours per week (Unconventional Policy)

[28] When I reduce θ_{NL} to θ_L, since both of $\frac{K}{L}$ and $\frac{EL}{E_1}L_1$ decrease, leading to a reduction in w_1, which represents the payment per unit of efficiency labor in nonlinear occupations. However, nonlinear workers with high labor disutility increase their productivity and receive a higher hourly wage, while those with lower labor disutility reduce their working hours due to the weakened nonlinearity. As a result, the overall wage level for a nonlinear worker increases.

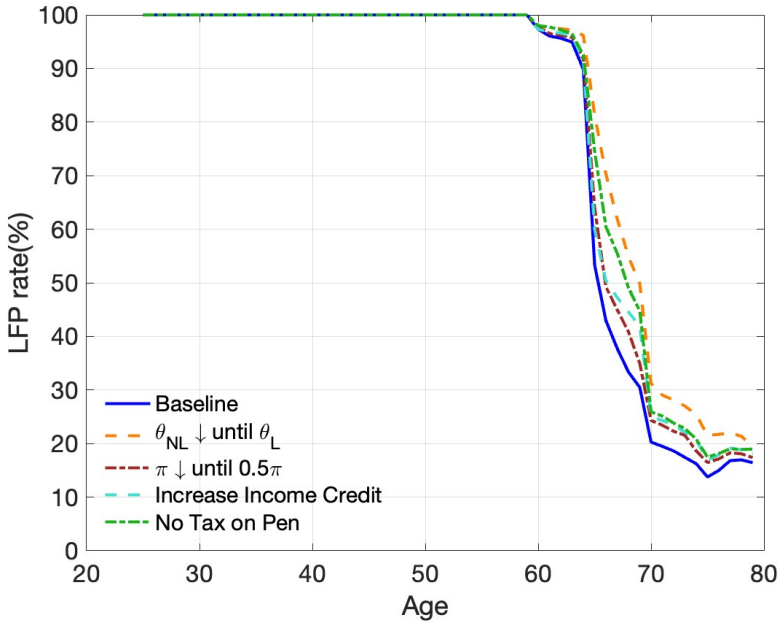


Figure 30: LFP (Unconventional Policy)

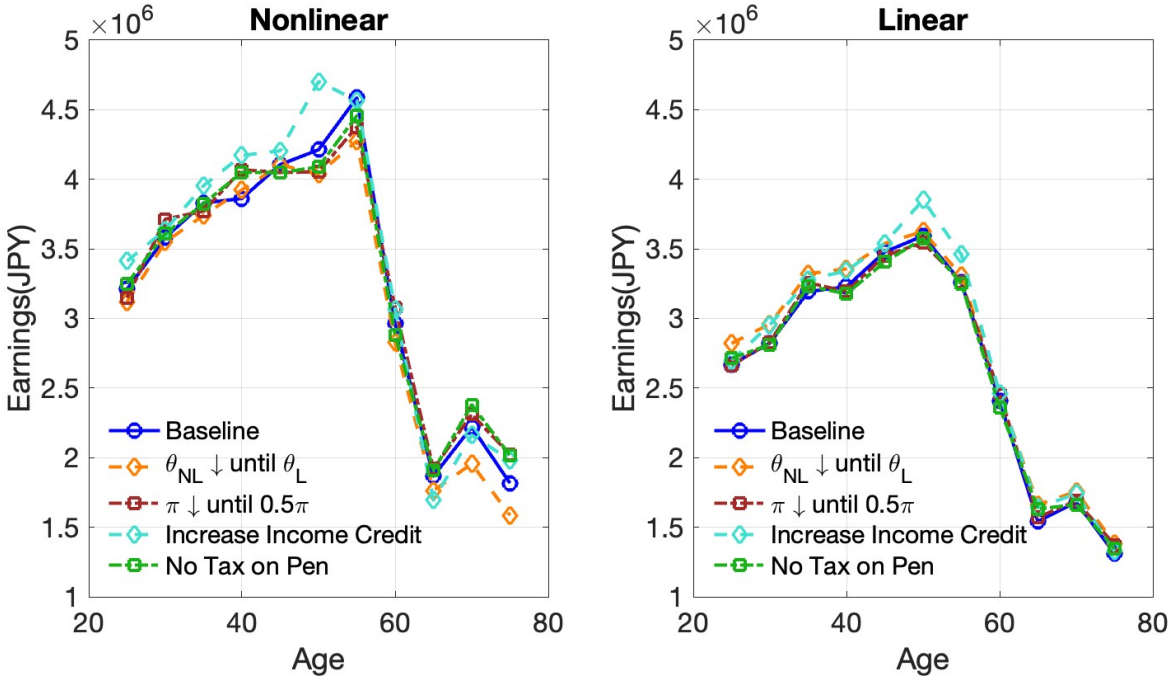


Figure 31: Earnings (Unconventional Policy)

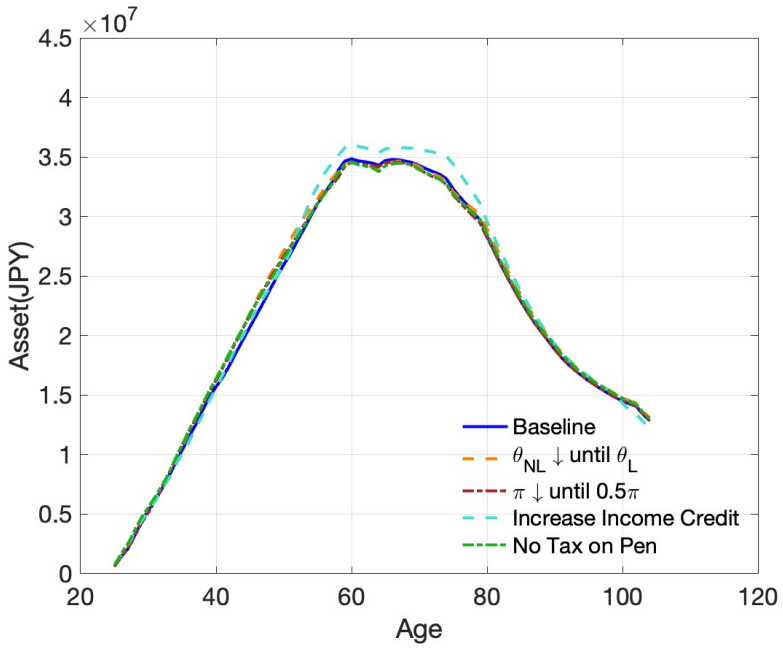


Figure 32: Asset (Unconventional Policy)