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The Effect of Retirement Age on Labor Productivity: A Macroeconomic Approach

Kazushige Matsuda[a]

In developed economies, the population is aging and social security expenditure is projected to increase. This paper examines the effect of increasing the retirement age at which people start receiving pension on human capital investment and labor productivity. I build a quantitative overlapping-generations model with endogenous human capital investment in the Ben-Porath style. I find that increasing the retirement age increases human capital investment and labor productivity. People work for longer years until the new retirement age, and thus they invest more in human capital while young. Increasing the retirement age by 2 years leads to a welfare improvement of 1.2%.

Keywords　Labor productivity, Human Capital, Pension, Retirement

1 Introduction

In developed economies, the population is aging. The number of people aged 65 or older world-wide is projected to increase from 9% in 2015 to 17% by 2050 (He, Goodkind, and Kowal (2016); Roberts et al. (2018)); social security expenditure is also projected to increase. Yet the government is required to cut social security expenditure to balance the budget. A possible reform would be to increase the retirement age, which I define as the age at which people start receiving a pension; in the United States, this is 66. This would not only reduce aggregate social security expenditure but could also affect the aggregate economy. For example, with an increase in the retirement age, people would have to work longer and the proportion of older workers in the labor force would likely increase. We thus need to evaluate the effects of increasing the retirement age on the aggregate economy.

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In this paper, I focus on what the effect would be of increasing the retirement age on labor productivity. We should focus on labor productivity for two reasons. First, Ben-Porath (1967) shows that human capital investment depends on working periods. To the extent that increasing the retirement age leads to longer working periods, agents have more time to use their own human capital. It follows that returns to human capital investment increase and human capital (or labor productivity) also increases. This mechanism is consistent with existing empirical papers. Second, increasing labor productivity can be a substitute for a decrease in the labor force due to aging. In aging economies, more people are retired and the labor force might be insufficient. We can maintain aggregate labor in the economy by increasing labor productivity (quality) even if the labor force (quantity) decreases.

In this paper, I build a heterogeneous overlapping-generations model as in Ben-Porath (1967), in which agents in the model endogenously split their time between human capital investment and production. Unlike Ben-Porath, agents also work and invest in human capital even after the retirement age. This assumption is important, because people in the United States work for a significant time after age 66. I calibrate the model to the current US earnings profile and laborhours decisions after the retirement age and examine the effect of increasing the retirement age on human capital investment and labor productivity.

I find that increasing the retirement age increases human capital investment and labor productivity. The mechanism is as follows. First, with an increase in the retirement age, income decreases. Therefore agents reduce leisure due to the income effect. Since they work for a longer period, returns to human capital investment increase. Second, with the borrowing constraint, young agents cannot borrow to invest in human capital and human capital is underinvested. After increasing the retirement age, I assume that the government reduces the labor income tax to balance the budget. Since the disposable income for young agents increases, they can increase human capital investment.

1. 1 Related Literature

This paper is mainly based on the literature on the effect of working life on human capital investment. Cervellati and Sunde (2013), Hansen and Strulik (2017), Jayachandran and Lleras-Muney (2009) and Oster, Shoulson, and Dorsey (2013) empirically show that an increase in life expectancy leads to educational investment. Montizaan, Cörvers, and De Grip (2010), Brunello and Comi (2015), and Fürstenau et al. (2020) empirically show that a decrease in pension payment increases human capital investment. In particular, Fürstenau et al. (2020) exploit a pension reform in regression discontinuity and find that an increase in working life increases training.

Echevarría and Iza (2006)'s motivation is the same as this paper's; they examine the effect of pension on human capital using a theoretical model. In contrast, I employ a quantitative model in which human capital investment is Ben-Porath style. I calibrate the model to match wage dynamics over the life-cycle and labor hours after retirement. I also quantitatively examine the size of the increase in labor productivity, output, and welfare. Blundell et al. (2021) and Fan, Seshadri, and Taber (2017) conduct structural analysis using a partial equilibrium model to show that a decrease in pension payment increases human capital investment. In contrast, I use a general equilibrium model and derive welfare implications. Vogel, Ludwig, and Börsch-Supan (2017) use a representative agent model to examine the effect of aging on the economy with an increase in the retirement age. In contrast, I employ a heterogeneous agent model and calibrate to match working hours after retirement, which is important to the change in human capital investment.

The closest paper is by Huggett, Ventura, and Yaron (2011), who study the sources of lifetime inequality using a quantitative Ben-Porath heterogeneous-agent model. They assume that agents stop working after the retirement age. I add the choice of labor and human capital investment after retirement age, which is important in understanding the effects of the retirement age.

Next, I use a quantitative overlapping-generations model to examine the effect of pension. De Nardi, Imrohoroğlu, and Sargent (1999); Conesa and Krueger (1999); Nishiyama and Smetters (2007); and Kitao (2014) examine the effect of social security reforms using quantitative models. Imrohoroğlu and Kitao (2012) study the effect of pension reform on labor supply decisions and benefit claims. They show that expansion of the retirement age leads to more capital in the model in which labor productivity is exogenous. In this paper, labor productivity also increases endogenously, together with physical capital.

2 Model

Time is discrete and each period in this model is 1 year. The economy is inhabited by a continuum of overlapping-generations households. Age is indexed by $j \in \{1, 2, \ldots, J\}$. Each household becomes economically independent at age 1 (biological age 19). They start getting pension at $J_R = 48$ (biological 66), which is the retirement age in the benchmark case (before the policy reform). The maximum age is $J = 82$ (biological 100). The survival rate from age j to

$j+1$ is ζ_j. I estimate ζ_j using the US Life Table 2010. I focus on a stationary equilibrium in which prices are invariant and abstract from time subscripts.

2. 1 Households

Each household has preferences represented by

$$\mathbb{E}_1 \quad \sum_{j=1}^{J} \tilde{\beta}_{j-1}\left(\frac{c_j^{1-\sigma}}{1-\sigma}-\phi_j\frac{(\ell_j+s_j)^{1+\nu}}{1+\nu}\right), \tag{1}$$

where c_j is consumption at age j and $\tilde{\beta}_j \equiv \beta^j(\prod_{j'=1}^{j}\zeta_{j'})$ the effective time discount rate including the time discount rate β and the survival rate ζ_j. Each household is endowed with one unit of time, which they spend on labor ℓ_j and human capital time investment s_j. They derive disutility from these two activities. I assume that this disutility depends on age and

$$\phi_j=\begin{cases} 0 & \text{if } j \leq J_O \\ \bar{\phi}(j-J_O+1)^{\phi_1} & \text{if } j > J_O. \end{cases} \tag{2}$$

The disutlity of labor and time investment is greater for older agents. I assume that the disutility is zero before period J_O (biological age 60).

Each agent starts their lives with initial human capital h_1 and learning ability θ, drawn from a log-normal joint distribution $\phi=LN(\mu_x, \Sigma)$, and no financial assets. $\mu_x=(\mu_h, \mu_\theta)$ are the means of log initial human capital and log learning ability. $(\sigma_h, \sigma_\theta, \rho_{h,\theta})$ are the standard deviations of log human capital, log learning ability, and their correlation.

The Bellman equation at age j with value function V_j is

$$V_j(a, h, \theta)=\max_{a',s,\ell}\left(\frac{c^{1-\sigma}}{1-\sigma}-\phi_j\frac{(\ell+s)^{1+\nu}}{1+\nu}\right)+\beta\zeta_j\mathbb{E}V_{j+1}(a', h', \theta) \tag{3}$$

subject to

$$(1+\tau_c)c+a' \leq \frac{(1+(1-\tau_k)r)}{\zeta_{j-1}}a+(1-\tau_\ell)wh\ell+T_j \tag{4}$$

$$h'=\exp(z)(h+\theta(hs)^\alpha) \tag{5}$$

$$\log z \sim N(\mu_z, \sigma_z^2) \tag{6}$$

$$0 \leq s+\ell \leq 1 \tag{7}$$

$$a' \geq 0. \tag{8}$$

Households' wages are the product of the price of effective labor w and human capital h. I assume that labor productivity is the same as human capital and use labor productivity interchangeably with human capital. They choose time on investment s and production ℓ, with time endowment fixed at one. Human capital investment is learning-or-doing, as in Ben-Porath. We can interpret human capital investment between age 1 and 4 (biological age 19 between 22) as college education. As households increase human capital investment, they can accumulate more human capital. However, when they work fewer hours-and thus have reduced income-they also need to cut consumption or asset holdings.

a is asset holdings and r is the return on assets. They spend income on consumption c and asset holding at the next period a'. I assume perfect annuity market, with which the assets of deceased individuals are distributed within the same cohort. Thus the asset is inflated by ζ_{j-1}. Households pay labor income tax whose rate is τ_ℓ, capital income tax whose rate is τ_k, and consumption tax whose rate is τ_c. Households also receive transfer T_j from the government, which depends on age j.

Equation (5) describes the law of motion of human capital. z depicts an idiosyncratic shock to human capital, which is log normally distributed with mean μ_z and standard deviation σ_z.

Importantly, agents face a borrowing limit $a' \geq 0$. In the laissez-faire equilibrium, human capital is underinvested. Since young agents have less income than middle-aged agents, they are more likely to hit the borrowing limit.

2.2 Production

There is a representative firm producing final goods from capital K and effective labor H following the production function

$$F(K, H) = K^\gamma H^{1-\gamma}. \tag{9}$$

They purchase capital and labor service at rent $r+\delta$ and wages w. δ is the capital depreciation rate. The capital and labor markets are competitive. The optimal conditions are

$$r = \gamma \left(\frac{K}{H}\right)^{\gamma-1} - \delta \tag{10}$$

$$w = (1-\gamma)\left(\frac{K}{H}\right)^{\gamma}. \tag{11}$$

2.3 Government

The government collects consumption, labor income, and asset income tax to spend on exogenous government consumption G and transfer. Defining $x = (a, h, \theta) \in X$ as the state variables for households,

$$\tau_c \sum_{j=1}^{J} \int_X c_j(x) d\mu_j + \tau_\ell w H + \tau_k r K = G + \sum_{j=1}^{J} T_j. \tag{12}$$

I assume that the transfer is

$$T_j = \begin{cases} \kappa_y \bar{y} & \text{if } j < J_R \\ \kappa_o \bar{y} & \text{if } j \geq J_R, \end{cases} \tag{13}$$

where $\overline{y}$ is the average labor income of the economy. In the U.S., T_j is considered to be an earned income tax credit before age J_R and social security after J_R. The combination of the proportional labor income tax and the transfer captures the U.S. progressive tax system in that the average tax rates vary with income.

2. 4 Equilibrium

Definition 1. *A stationary equilibrium is a list of value function $V_j(x)$; decision rules of consumption, asset holdings, labor hours, and human capital time investment $c_j(x)$, $a_j'(x)$, $\ell_j(x)$, and $s_j(x)$; aggregate capital and labor inputs K, H; prices r, w; policy τ_ℓ; and measures $\mu=\{\mu_j(x)\}_j$ such that*

1. *Taking prices and policy as given, value functions $V_j(x)$ solve the household Bellman equation and $c_j(x)$, $a_j'(x)$, $\ell_j(x)$, $s(x)$ are associated decision rules.*
2. *Taking prices and policy as given, K and H solve the optimization problem of the firm.*
3. *The government budget is balanced.*
4. *Labor and asset markets clear.*

$$H=\sum_{j=1}^{J}\int_X h\ell_j(x)d\mu_j,\ K=\sum_{j=1}^{J}\int_X a_j'(x)d\mu_j. \tag{14}$$

Table 1: Externally calibrated parameters

Parameter	Description	Value
σ	interemporal elas substitution	2
β	time discount rate	0.98
γ	capital share	0.322
δ	depreciation	0.067
ν	Frisch elasticity	2
μ_z	mean human capital shock	−0.029
σ_z	std human capital shock	0.11
τ_c	consumption tax rate	0.07
τ_ℓ	labor income tax rate	0.22
τ_k	capital income tax rate	0.27
κ_y	welfare payments to income	0.03
κ_o	pension replacement rate	0.4

5. *Measures μ are reproduced for each period.*

3 Calibration

There are two sets of parameters to calibrate. The first set is externally calibrated using the earlier literature. The second set is calibrated solving the equilibrium of the model given the parameters of the first set. Mainly I target year 2010 for the benchmark case.

Table 1 shows the parameter values set externally. The intertemporal elasticity of substitution is set to $\sigma=2$. The time discount rate β, the capital share γ, and depreciation δ are set to 0.98, 32.2%, and 6.7% as in Huggett, Ventura, and Yaron (2011). Frisch elasticity is set to the standard value $\nu=2$.

The mean and standard deviation of human capital shock μ_z and σ_z are from Huggett, Ventura, and Yaron (2011). They estimate these parameters using people in the US around aged 60-65 and assuming that agents do not work after age 60 and do not invest in human capital right before age 60. Although I assume that agents can work after age 60, the working population after age 60 is still very small and estimates are not accurate if I target people aged around 80, which is the final working age in this model. Therefore I use the same estimates as Huggett et al. μ_z is negative and the mean of human capital shock is less than one. It follows that if agents do not invest in human capital, human capital stock decreases; this is interpreted as depreciation of human capital.

Tax rates τ_c, τ_ℓ, and τ_k are from McDaniel (2007). The welfare payment rate κ_y and the replacement ratio of pension κ_o are from Lee and Seshadri (2019).

Table 2: Internally calibrated parameters

Parameters	Interpretation	Value
α	human capital investment elasticity	0.52
μ_h	mean of initial human capital	4.45
σ_h	std of initial human capital	0.14
μ_θ	mean of learning ability	-0.39
σ_θ	std of learning ability	0.012
$\rho_{h,\theta}$	correlation between init human capital and ability	0.043
$\overline{\phi}$	labor disutility intercept	0.0040
ϕ_1	labor disutility slope	1.36
G	government consumption	12.2

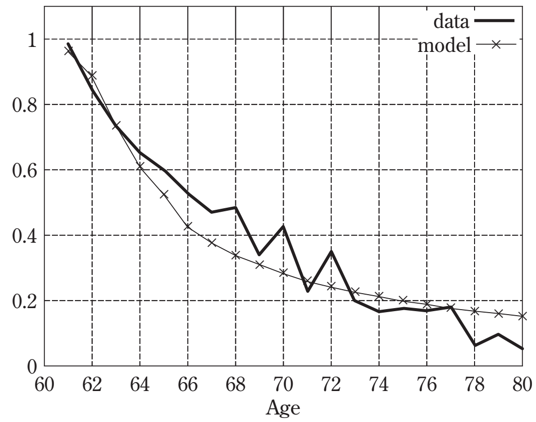
3.1 Simulated method of moments

Nine remaining parameters remain to be calibrated, as in Table 2. I use the share of working time for people aged 60 or older from the Panel Study of Income Dynamics (PSID) after year 2010 as first moments. I normalize working time such that the working time is 1 at age 60 after year 2010. $\overline{\phi}$ and $\overline{\phi}_j$ help match these moments.

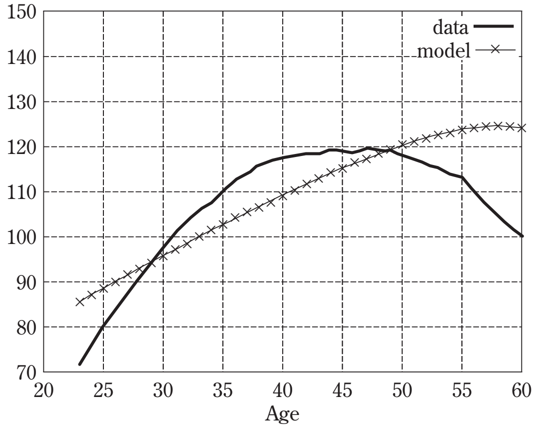
Next, I target mean earnings from age 23 to 60. α, μ_h, μ_θ, and $\rho_{\theta,h}$ help match these moments. Third, I target the variance of log earnings. σ_h and σ_θ help match these moments. I use the estimates of the mean of earnings and the variance of log earnings from Huggett, Ventura, and

Figure 1: Moments matched.

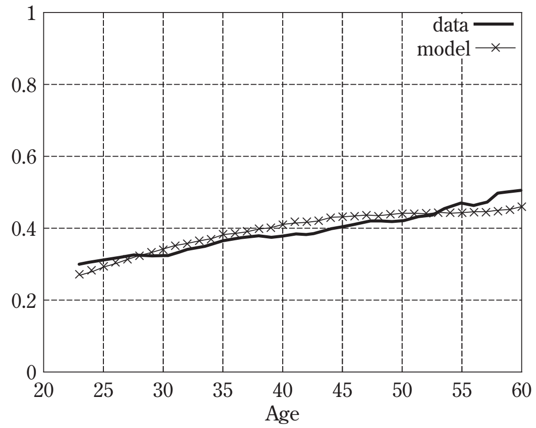
(a) Working hours



(b) Mean earnings



(c) Var of log earnings



Yaron (2011).

Finally, exogenous government consumption G is targeted at 17.8% of aggregate output in the benchmark case, as in the United States in 2015.

The third column of Table 2 shows the calibrated parameter values. $\rho_{h,\theta}$ is positive, which implies that learning ability and human capital stock at age 23 are positively correlated. Agents have high human capital stock at age 23 because they had learning ability before age 23. This explains why they are positively correlated. ψ_1, the slope of labor disutility, is positive, which implies that the disutility of working or investing in human capital is increasing as agents become older.

Figure 1 presents the model fit of these moments. Overall, the model matches working hours and wage profiles well, but not mean earnings. Mean earnings in the model are flatter than in the data. This pattern in the discrepancy between the model and the data is also observed in Huggett, Ventura, and Yaron (2011). However, this model captures the basic pattern whereby mean earnings increase but start to decrease before age 60. Working hours after age 60 are matched well, which gives me confidence regarding the functional form of disutility ψ_j.

I test the external validity of the model using the change in mean labor earnings from age 60 and the model matches it well.

4 Results

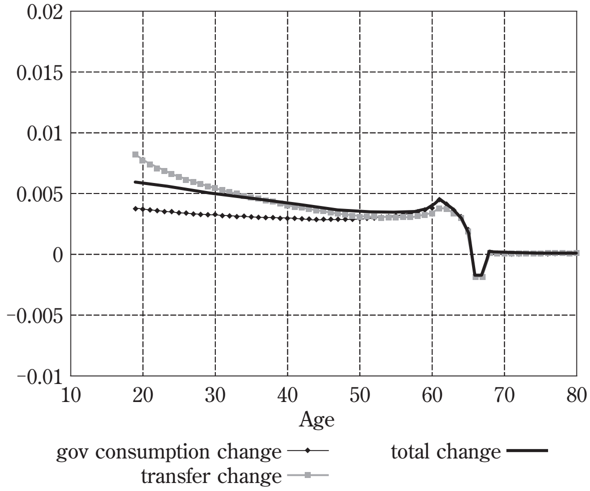
I conduct a policy experiment in this section. I increase the age at which agents start to receive pension by 2 years in the model, from age 66 to 68. The government balances the budget by adjusting the labor income tax rate.

I show the effect on human capital investment. The solid line of the top panel in Figure 2 shows the percentage change in human capital investment before and after increasing the retirement age. If it is positive, human capital investment is greater than the benchmark case and vice versa. By increasing the retirement age, time for human capital investment increases for all young ages by more than 0.5 percentage point.

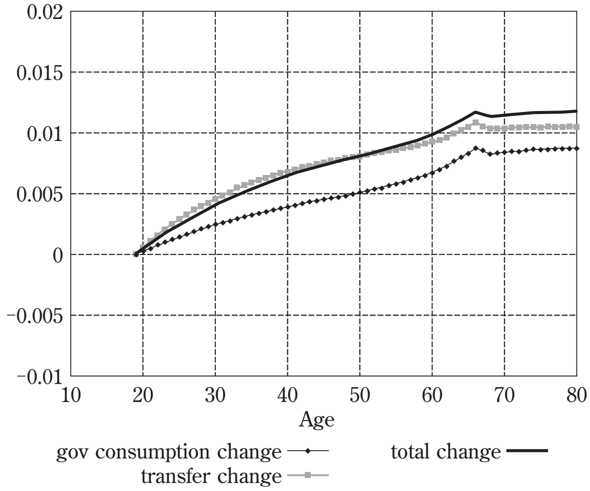
The effect of increasing the retirement age can be decomposed into three parts. First, the decrease in pension induces agents to accumulate human capital because of the income effect. Second, the cut in pension comes with a decrease in the labor income tax rate to balance the budget. There is more disposable income for young agents and they can increase human capital investment more. Third, the distortative labor income tax rate decreases and the return on human capital investment increases (substitution effect).

Figure 2: Change in human capital investment and labor productivity from the benchmark: Decomposition.

(a) Human capital investment



(b) Labor productivity



To quantify each effect, I study three counterfactuals corresponding to each case. For the first mechanism, I assume that government consumption G changes instead of the labor income tax rate. In this scenario, the loss of pension is not offset by a decrease in tax and lifetime wealth decreases. For the second mechanism, I assume the government increases transfer to young agents κ_y instead of changing the labor income tax rate. While lifetime wealth is compensated for by an increase in the transfer while young, there is no distortion from labor income tax changes. The last mechanism corresponds to the case in which the labor income tax is changed, which is the total effect.

Figure 2 shows the decomposition for human capital investment and labor productivity. In the case of government consumption change, depicted as the line with circles, human capital investment increases. Since agents need more income for consumption after retirement, they work longer, which increases returns to human capital investment. As a consequence, human capital investment increases by 0.3 percentage point before the retirement age.

Next, consider the case in which lump-sum transfer κ_y adjusts, depicted as the line with squares. These agents increase human capital investment even more while young. With an increase in lump-sum transfer for young agents, they have more income and can increase human capital investment by 0.3 more percentage point.

Table 3: The aggregate effect of policy changes.

	Benchmark	Increasing pension age
Labor income tax rate	22.0%	20.5%
Human capital investment	13.0%	13.3%
Labor productivity		+0.7%
Hours		−0.1%
Output		−1.3%
Consumption		+1.0%
Welfare (CEV)		+1.2%

Finally, consider the case in which the labor income tax adjusts, which is the solid line. Young agents decrease human capital investment compared with the case of transfer change. Young agents have lower income, so their total labor income tax cut is not large compared with middle-aged agents whose income, and the total tax cut, is high. Therefore human capital investment shifts from young age to middle age compared with the case of transfer change. The bottom panel of Figure 2 shows the difference in aggregate labor productivity, which increases faster in all three cases than the benchmark case.

Table 3 shows changes in aggregates. The second column shows that increasing the retirement age reduces the labor income tax rate to balance the budget, because the total pension is reduced, more people work longer overall, and the tax base increases. It also increases human capital investment by 0.3 percentage points. As a result, labor productivity increases by 0.7%. With learning-or-doing, aggregate hours decrease by 0.1%. Output and consumption increase by 1.3% and 1.0%, respectively. Welfare improves by 1.2% in terms of lifetime consumption equivalence. The mechanism is as follows. First, a decrease in the labor income tax reduces distortion of human capital investment. The decrease in the labor income tax rate increases disposable income for young agents facing the borrowing limit and enables them to increase human capital investment.

5 Conclusion

This paper examines the effect of increasing the retirement age on human capital investment and labor productivity. Increasing the retirement age helps balance the government budget in the aging economy, induces people to work longer, and increases the labor force. This paper shows that there is an additional effect: increasing human capital investment. With increased retirement age, people keep working after retirement and thus they invest more in human capital while young.

I abstract from important institutional details such as early and delayed claiming. Although they are actuarially equivalent with average life expectancy and it might not have a significant impact on the main results, it would be interesting to examine how changing the retirement age might affect people heterogeneous with regard to life expectancy.

The paper's findings suggest avenues for future work. In an aging economy, it is important to integrate labor and human capital investment choices after the retirement age. Health can increase the expected working hours after retirement, and healthcare policy can affect human capital investment. Thus we can extend the model to include health shocks and healthcare policy in future work.

A Computation of Stationary Equilibrium

This section describes the method for computing an equilibrium.

1. Start from an initial vector of aggregate variables $w=(r, w, \tau_l)$.
2. Given these variables, solve individuals' decision problems. This step consists of sub-steps.
   (a) Solve backward the Bellman equations for age $j=J, \ldots, 1$. The number of grids for assets is 30. Apply the endogenous grid method.
   (b) Given the converged V_0, solve the decision rules of individuals until convergence.
3. Starting from an initial measure μ_1 and given decision rules, solve forward from μ_1 to μ_J .
4. Given the measures, derive the new aggregate variables K, H, and τ_l from the government budget constraint. Compute the new prices from the first-order conditions of the representative firm and go back to step 2.

References

Ben-Porath, Yoram. 1967. "The production of human capital and the life cycle of earnings." *Journal of Political Economy* 75(4, Part 1): 352-365.

Blundell, Richard, Monica Costa-Dias, David Goll, and Costas Meghir. 2021. "Wages, Experience, and Training of Women over the Life Cycle." *Journal of Labor Economics* 39(S1): S275-S315.

Brunello, Giorgio, and Simona Comi. 2015. "The side effect of pension reforms on the training of older workers. Evidence from Italy." *The Journal of the Economics of Ageing* 6: 113–122.

Cervellati, Matteo, and Uwe Sunde. 2013. "Life expectancy, schooling, and lifetime labor supply: theory and evidence revisited." *Econometrica* 81(5): 2055–2086.

Conesa, Juan C, and Dirk Krueger. 1999. "Social security reform with heterogeneous agents." *Review of Economic dynamics* 2(4): 757–795.

De Nardi, Mariacristina, Selahattin Imrohoroğlu, and Thomas J Sargent. 1999. "Projected US demographics and social security." *Review of Economic Dynamics* 2(3): 575–615.

Echevarría, Cruz A, and Amaia Iza. 2006. "Life expectancy, human capital, social security and growth." *Journal of Public Economics* 90(12): 2323–2349.

Fan, Xiaodong, Ananth Seshadri, and Christopher Taber. 2017. "Understanding earnings, labor supply, and retirement decisions." *Michigan Retirement Research Center Research Paper*, no. 2017–367.

Fürstenau, Elisabeth, Niklas Gohl, Peter Haan, and Felix Weinhardt. 2023. "Working life and human capital investment: Causal evidence from a pension reform." *Labour Economics* 84: 102426.

Hansen, Casper Worm, and Holger Strulik. 2017. "Life expectancy and education: evidence from the cardiovascular revolution." *Journal of Economic Growth* 22(4): 421–450.

He, Wan, Daniel Goodkind, and Paul Kowal. 2016. An aging world: 2015.

Huggett, Mark, Gustavo Ventura, and Amir Yaron. 2011. "Sources of lifetime inequality." *American Economic Review* 101(7): 2923–2954.

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

Jayachandran, Seema, and Adriana Lleras-Muney. 2009. "Life expectancy and human capital investments: Evidence from maternal mortality declines." *The Quarterly Journal of Economics* 124(1): 349–397.

Kitao, Sagiri. 2014. "Sustainable social security: Four options." *Review of Economic Dynamics* 17(4): 756–779.

Lee, Sang Yoon, and Ananth Seshadri. 2019. "On the intergenerational transmission of economic status." *Journal of Political Economy* 127(2): 855–921.

McDaniel, Cara. 2007. "Average tax rates on consumption, investment, labor and capital in the OECD 1950–2003." *Manuscript, Arizona State University*, vol. 19602004.

Montizaan, Raymond, Frank Cörvers, and Andries De Grip. 2010. "The effects of pension rights and retirement age on training participation: Evidence from a natural experiment." *Labour Economics* 17(1): 240–247.

Nishiyama, Shinichi, and Kent Smetters. 2007. "Does social security privatization produce efficiency gains?" *Quarterly Journal of Economics* 122(4): 1677–1719.

Oster, Emily, Ira Shoulson, and E Dorsey. 2013. "Limited life expectancy, human capital and health investments." *American Economic Review* 103(5): 1977–2002.

Roberts, Andrew W, Stella U Ogunwole, Laura Blakeslee, and Megan A Rabe. 2018. *The population*

65 years and older in the United States: 2016. US Department of Commerce, Economics and Statistics Administration.

Vogel, Edgar, Alexander Ludwig, and Axel Börsch-Supan. 2017. “Aging and pension reform: extending the retirement age and human capital formation.” *Journal of Pension Economics & Finance* 16(1): 81–107.