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December 2016

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Working Paper 10/2016

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Abstract

We show that the long-run economic growth effect of an increase in the retirement age is unambiguously positive in research and development based endogenous growth models. This contrasts recent findings based on models of learning-by-doing-spillovers, in which an increase in the retirement age reduces physical capital accumulation and thereby economic growth. Our results imply that models based on learning-by-doing-spillovers, which are often used as a short-cut formulation for research and development based growth models, do not necessarily lead to similar policy conclusions.

JEL classification: J10, J26, O30, O41.
Keywords: demographic change, pension reform, long-run economic growth, R&D-based growth.

1 Introduction

We analyze the long-run growth effects of raising the retirement age in modern knowledge-based economies as described by research and development (R&D) based growth frameworks a la Romer (1990). We show that an increase in the retirement age unambiguously raises economic growth because the positive growth effect of the larger workforce overcompensates the negative growth effect of reduced savings. While it is often argued that the results of endogenous growth models based on learning-by-doing spillovers a la Romer (1986) are similar to those based on Romer (1990), we show that this is not the case for an increase in the retirement age.

Our results are closely related to those of Futagami and Nakajima (2001) and Heijdra and Mierau (2011) who find that the increase in the retirement age leads to a reduction of capital accumulation and therefore to a reduction of economic growth in a Romer (1986) setting. While their results are most relevant for economies in which growth is driven by physical capital accumulation and which tend to adopt technologies from abroad (mostly small open economies), our results imply the opposite effect in countries that actively advance the world-wide knowledge frontier.

2 The model

2.1 Households

Consider an economy in which individuals enter the labor market as adults at time t_0 and maximize their discounted stream of lifetime utility given by

$$U = \int_{t_0}^{\infty} \log(c) e^{-(\rho+\mu)(t-t_0)} dt,$$

where c is instantaneous consumption, ρ is the discount rate, and μ represents the mortality rate that augments the discount rate. Individuals earn non-capital income w (wages and lump-sum re-distributions of profits from intermediate goods producers) as long as they are not retired. Suppressing time arguments and following Yaari (1965) in assuming that there exists a fair life insurance company at which individuals insure against the risk of dying with positive capital holdings, the flow budget constraint of individuals reads

$$\dot{k} = \chi w + (\mu + r)k - c, \tag{1}$$

where k denotes the individual capital stock and χ is an indicator function with value 1 when working and 0 when retired. Solving the intertemporal maximization problem leads to the standard Euler equation

$$\dot{c} = (r - \rho)c$$

stating that consumption expenditure growth is positive if and only if the interest rate exceeds the time discount rate. Recognizing that lifetime consumption expenditures have to be equal to lifetime income, the lifetime budget constraint can be written as

$$\int_{t_0}^{\infty} e^{-(\mu+r)(t-t_0)} c(t_0,t)dt \quad = \quad \int_{t_0}^{t_0+R} e^{-(\mu+r)(t-t_0)} w(t_0,t)dt,$$

where the working life span is denoted by R such that the age at retirement is given by $t_0 + R$. Assuming that t_0 is constant, an increase in R is tantamount to an increase in the retirement age.

Denoting the aggregate capital stock by K and aggregate consumption expenditures by C we have the following aggregation rules (see for example Blanchard, 1985; Heijdra and van der Ploeg, 2002):

$$K(t) \equiv \int_{-\infty}^{t} k(t_0,t)N(t_0,t)dt_0, \tag{2}$$

$$C(t) \equiv \int_{-\infty}^{t} c(t_0,t)N(t_0,t)dt_0, \tag{3}$$

where $N(t_0,t)$ denotes the size of the cohort entering the labor market at time t_0 as of date t, while $k(t_0,t)$ and $c(t_0,t)$ are the capital holdings and consumption levels of its members, respectively. To capture the Romer (1990) case of a stationary population, we assume that the birth rate equals the death rate such that the flow of labor market entrants is $N(t,t) = \mu N(t)$, where $N(t) = \int_{-\infty}^{t} N(t_0,t)dt_0 \equiv N$ represents the adult population size and $L(t) = \int_{t-R}^{t} N(t_0,t)dt_0$ is the labor force. Note that each adult cohort is of size $\mu N e^{\mu(t_0-t)}$ at a certain date $t > t_0$. Taking into account this demographic structure leads to the following dynamic equations for the aggregate capital stock and for aggregate consumption, respectively,

$$\dot{K} = rK + W - C, \tag{4}$$

$$\frac{\dot{C}}{C} = r - \rho - \mu(\rho+\mu)\frac{K}{C}, \tag{5}$$

where W refers to aggregate non-capital income. The economy-wide resource constraint states that everything that is produced but not consumed is invested in physical capital such that the goods market clearing condition is

$$\dot{K} = Y - C, \tag{6}$$

with Y referring to the economy's GDP.

2.2 Firms

The final goods sector produces the consumption aggregate with labor and machines according to

$$Y = L_Y^{1-\alpha} \int_0^A x_i^\alpha di, \tag{7}$$

where L_Y refers to labor used in final goods production, A is the technological frontier, x_i is the amount of a certain specific machine i used in final goods production, and $\alpha \in (0,1)$ is the elasticity of final output with respect to machines. Perfect competition implies that the wage rate, w_Y, and the prices of machines, p_i, are given by

$$w_Y = (1-\alpha)\frac{Y}{L_Y}, \tag{8}$$

$$p_i = \alpha L_Y^{1-\alpha} x_i^{\alpha-1}. \tag{9}$$

Each intermediate firm produces one of the differentiated machines such that there is monopolistic competition in the vein of Dixit and Stiglitz (1977). After a firm has purchased a blueprint, it has access to the linear production technology $k_i = x_i$. Thus, operating profits can be written as

$$\pi_i = p_i k_i - r k_i = \alpha L_Y^{1-\alpha} k_i^\alpha - r k_i. \tag{10}$$

Profit maximization of firms yields prices of machines as $p_i = r/\alpha$, where $1/\alpha$ is the markup over marginal cost. The aggregate capital stock is equal to the amount of all intermediates produced, i.e., $K = Ax$, such that equation (7) becomes $Y = (AL_Y)^{1-\alpha} K^\alpha$. Consequently, production per capital unit can be written as a function of the interest rate and the elasticity of final output with respect to machines such that $r = \alpha p = \alpha^2 Y/K \Rightarrow Y/K = r/\alpha^2$.

The R&D sector employs scientists to discover new blueprints. Depending on the productivity of scientists, λ, the stock of blueprints evolves according to

$$\dot{A} = \lambda A L_A, \tag{11}$$

where L_A denotes the employment level of scientists. Research firms maximize their profits $\pi_A = p_A \lambda A^\phi L_A - w_A L_A$, with p_A representing the price of a blueprint, by choosing the employment level, L_A. The first-order condition pins down wages in the research sector as $w_A = p_A \lambda A$. Due to perfect labor mobility, wages of workers in the final goods sector and wages of scientists equalize and we get the equilibrium condition

$$w_A = p_A \lambda A = (1-\alpha)\frac{Y}{L_Y} = w_Y. \tag{12}$$

Firms in the R&D sector charge prices for blueprints that are equal to the present value of operating profits in the intermediate goods sector because there is always a potential entrant who is willing to outbid a lower price. Consequently, $p_A = \int_t^\infty e^{-R(\tau)}\pi \, d\tau$, where the discount rate is the market interest rate: $R(\tau) = \int_t^\tau r(s) \, ds$. Via the Leibniz rule and the fact that prices of blueprints do not change along a balanced growth path (BGP), we obtain $p_A = \pi/r$, i.e., prices of blueprints are equal to the discounted stream of operating profits for intermediate goods producers. Next, by using Equation (10), we derive operating profits as $\pi = (1-\alpha)\alpha Y/A$ such that the price of blueprints becomes $p_A = (1-\alpha)\alpha Y/(rA)$. Using the labor market clearing condition $L = L_A + L_Y$, we can determine the amount of labor employed in the final goods sector and in the R&D sector by using Equation (12) as

$$L_Y = \frac{r}{\alpha\lambda}, \qquad L_A = L - \frac{r}{\alpha\lambda}. \tag{13}$$

Inserting (13) into (11) leads to the evolution of technology as

$$\dot{A} \;=\; \max\left\{\lambda AL - \frac{rA}{\alpha}\;,\;0\right\}. \tag{14}$$

2.3 Results

Along a BGP, we know that $\dot{A}/A = \dot{C}/C = \dot{K}/K = g$. Collecting equations (5), (6), (14), recalling that labor supply is given by $L(t) = \int_{t-R}^t N(t_0, t) \, dt_0$, and utilizing the definition $C/K \equiv \xi$, we can derive the following three-dimensional system describing our model economy along the BGP

$$g \;=\; \frac{r}{\alpha^2} - \xi, \tag{15}$$

$$g \;=\; r - \rho - \mu(\rho+\mu)\frac{1}{\xi}, \tag{16}$$

$$g \;=\; \lambda \int_{t-R}^t N(t_0, t) \, dt_0 - \frac{r}{\alpha}, \tag{17}$$

where the endogenous variables are r, g, and ξ. At this stage we can state our main result.

Proposition 1. *In an overlapping generations version of the endogenous growth framework of Romer (1990) that takes retirement into account, an increase in the retirement age (a rise in R) leads to an increase in the interest rate (r) and to an increase in the long-run economic growth rate (g).*

Proof. Noting that $\int_{t-R}^t N(t_0, t) \, dt_0 = N\left(1 - e^{-\mu R}\right)$, we rewrite the system (15)-(17) as

$$W(\xi, g, r) := \frac{r}{\alpha^2} - \xi - g = 0, \tag{18}$$

$$X(\xi, g, r) := r - \rho - \mu(\rho+\mu)\frac{1}{\xi} - g = 0, \tag{19}$$

$$Y(\xi, g, r) := \lambda N\left(1 - e^{-\mu R}\right) - \frac{r}{\alpha} - g = 0. \tag{20}$$

Applying the implicit function theorem and Cramer's rule, we obtain the following comparative statics

$$\frac{dg}{dR} = \frac{\lambda \mu N e^{-\mu R}\left[\alpha^2\xi^2 + \mu(\mu+\rho)\right]}{(1+\alpha)\left[\alpha\xi^2 + \mu(\mu+\rho)\right]} > 0,$$
$$\frac{dr}{dR} = \frac{\alpha^2 \lambda \mu N e^{-\mu R}\left[\mu(\mu+\rho) + \xi^2\right]}{(1+\alpha)\left[\alpha\xi^2 + \mu(\mu+\rho)\right]} > 0.$$

□

Hence, in contrast to Futagami and Nakajima (2001) and Heijdra and Mierau (2011), who base their analysis on a Romer (1986) framework, an increase in the retirement age unambiguously raises economic growth in a Romer (1990) setting. The intuition for this result is that a rise in the retirement age implies an increase in the labor force and therefore it raises the number of scientists that are available for the production of blueprints in the R&D sector. While there is also a reduction in individual savings due to the longer working-life (as in the other papers cited above), the associated negative growth effect is overcompensated by the positive effect of the larger labor force.

Remark 1. *The impact of an increase in the retirement age would follow a similar mechanism as the one described here if we were using a semi-endogenous growth model a la Jones (1995) without the strong scale effect as baseline framework. However, the growth effect itself would be transient and vanish in the long run, i.e., increasing the retirement age would have a positive level effect on per capita GDP but no long-run growth effect.*

3 Conclusions

Using an R&D-based growth model of the Romer (1990) type we showed that a rise in the retirement age implies faster long-run economic growth. This contrasts with recent findings based on the framework of Romer (1986) in which an increase in the retirement age reduces physical capital accumulation and thereby economic growth. Our result illustrates that Ak-type of growth models do not necessarily lead to similar policy conclusions as models of R&D-based economic growth.

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ECON WPS

Vienna University of Technology Working Papers
in Economic Theory and Policy

ISSN 2219-8849 (online)
http://www.econ.tuwien.ac.at/wps/

December 2016

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