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A note on social security, human capital and growth

Joachim Thøgersen
Oslo Metropolitan University

Abstract

In this paper we study the effect of an old-age public pension scheme, when growth is triggered by human capital accumulation. In Zhang (1995) and Kemnitz and Wigger (2000), it is shown that introducing an unfunded pension system in a Laissez-Faire economy will increase economic growth. The present paper follows Kemnitz and Wigger, but shows that a properly designed public funded system will also generate higher economic growth than a Laissez-Faire economy. Moreover, it is shown how capital intensity is affected by the funded pension scheme.

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Contact: Joachim Thøgersen - joachim.thogersen@oslomet.no.

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1 Introduction

The present paper investigates how a public funded pension system affects economic growth. A classical result in the theoretical literature is that a pay-as-you-go (PAYG) system will reduce economic growth, when growth is triggered by physical capital accumulation (Diamond, 1965; Saint-Paul, 1992; Wiedmer, 1996). However, in Zhang (1995) and Kemnitz and Wigger (2000), they assume that human capital is the engine of growth, and is then able to provide a counterexample to this classical result. They show that a PAYG scheme generates higher economic growth than a Laissez-Faire economy. Notice that they use a Laissez-Faire economy to represent the funded pension system. In Kemnitz and Wigger, human capital accumulation depends on the previous stock of human capital, and requires that succeeding generations inherit part of their human capital stock. Moreover, they apply a pension function that directly relates pension payments to study time. Accordingly, the PAYG pension system stimulates economic growth by internalizing the spillover effect on the productivity of future generations that is ignored in a Laissez-Faire economy.

However, many countries consider and conduct pension reforms toward more funded systems. It is therefore interesting to see whether a properly designed public funded pension system can deliver the same result as the PAYG system. The purpose of the present paper is thus to compare economic growth in a Laissez-Faire economy and a public funded economy, in a framework close to Kemnitz and Wigger. The only essential departure from their set up is the pension system. In particular, we ask if Proposition 3 in Kemnitz and Wigger (2000) also holds if the social security system is funded.

The public funded pension scheme must be distinct from both a PAYG scheme and a fully funded scheme. The system is similar to a PAYG system regarding the direct effect of skill acquisition on pensions, but it differs with respect to the funding element. In a funded system the contribution takes place in one period, and the pension benefit is paid out in the next period. Hence, the contributors finance their own old-age pensions.

In the current paper it is shown that the relation between investments in human capital and the pension scheme is not dependant on a PAYG system per se, but rather on a system that captures this specific link. Specifically, it is shown that a public funded system can deliver the same result as a PAYG system. This clear-cut result represents a novelty and fills a gap in the theoretical literature.

The paper is organized as follows. In Section 2 we develop the model. Section 3 investigates growth in the long-run and compares the public funded system with the Laissez-Faire economy. Section 4 concludes.

2 The model

2.1 Production and human capital

In each period t, production occurs according to a neoclassical production function $F(K_t, H_t)$, where F is homogenous of degree one, K_t is physical capital, and H_t is labor efficiency units. The production function in intensive form is given by $y_t = f(\kappa_t)$, with $y_t := Y_t/H_t$ and $\kappa_t := K_t/H_t$, where κ denotes capital intensity.

A single worker's human capital, depends on study time and human capital at time $t-1$: $h_t = \psi(\lambda_t)h_{t-1}$, where $\psi''(\cdot) < 0 < \psi'(\cdot)$, and $\lambda_t \in (0,1)$, is an endogenous choice variable and denotes the fraction of time spent on studying or education. Labor in efficiency units is determined by $H_t = (1-\lambda_t)h_t$.

Given the wage per efficiency unit of labor and capital return, w_t and R_t respectively, producers choose capital and labor to maximize profits. This implies the following first order conditions:

$$R_t = f'(\kappa_t) \quad \text{and} \quad w_t = f(\kappa_t) - \kappa_t f'(\kappa_t) =: \omega(\kappa_t)\,. \tag{1}$$

2.2 Individuals and the pension function

Each individual lives for two periods, young and old. Preferences for a representative individual born at t, are described by a time-separable isoelastic utility function:

$$u(c_{1,t}, c_{2,t+1}) = \frac{c_{1,t}^{1-\gamma}}{1-\gamma} + \rho\frac{c_{2,t+1}^{1-\gamma}}{1-\gamma}\,, \tag{2}$$

where $c_{1,t}$ is consumption as young in period t, $c_{2,t+1}$ is consumption as old in period $t+1$, $\rho \in (0,1)$ is the utility discount factor, and $\gamma > 0$ and $\gamma \neq 1$ is the elasticity of substitution between consumption in period 1 and 2. This utility function implies that there is no direct effect of λ_t and h_t on utility, only an indirect effect via lifecycle income.

Young workers contribute to the social security system with a proportional tax rate $\tau_t \in (0,1)$. During old-age, individuals receive the proceeds of their savings, S_t, along with their pension benefits, P_t. Budget constraints are:

$$c_{1,t} = (1-\tau_t)w_t h_t(1-\lambda_t) - S_t\,, \tag{3}$$

$$c_{2,t+1} = R_{t+1}S_t + P_{t+1}\,. \tag{4}$$

Pension payments are positively linked to time spent on human capital accumulation and former wage income:

$$P_{t+1} = \Theta(\lambda_t)w_t h_t(1-\lambda_t)\,, \tag{5}$$

where $\Theta(\lambda_t)$ represents the effect of time spent on human capital accumulation on pension receipts. Because pension benefits depends on both study time and working time, $\Theta(\cdot)$ is assumed to be strictly increasing and concave in λ_t, i.e. $\Theta'(\lambda_t) > 0$ and $\Theta''(\lambda_t) < 0$.

Note that an increase in human capital affects pension payments in two ways. First, investment in human capital affects pensions via the effect on wage income. This indirect effect is ambiguous, as study time raises the wage per hours worked, but reduces the number of working hours. Second, investment in human capital is assumed to have a direct positive effect on pensions apart from the effect via wage income. This channel ensures that the positive spillover of investments in human capital on the productivity of future generations is internalized by the public pension system. The pension function in (5) is related to the one used in Kemnitz and Wigger (2000), except that they only include the second and direct effect from skill acquisition to pensions.

Combining the individual's budget constraints, inserting human capital accumulation and the pension function in (5) gives the following lifecycle income:

$$W_t := \psi(\lambda_t) w_t h_{t-1}(1-\lambda_t)\left(1-\tau_t+\frac{\Theta(\lambda_t)}{R_{t+1}}\right). \tag{6}$$

Maximizing utility subject to (6) gives the savings function as:

$$S_t = \frac{w_t h_t(1-\lambda_t)}{1+(\rho R_{t+1})^{-\frac{1}{\gamma}} R_{t+1}}\left[1-\tau_t-\theta(\lambda_t)\,(\rho R_{t+1})^{-\frac{1}{\gamma}}\right]. \tag{7}$$

In a Laissez-Faire economy $\tau_t = \Theta(\lambda_t) = 0$, for all t. Thus, lifecycle income becomes:

$$W_t := \psi(\lambda_t) h_{t-1} w_t (1-\lambda_t)\,, \tag{8}$$

and optimal savings is given by:

$$S_t = \frac{w_t h_t(1-\lambda_t)}{1+(\rho R_{t+1})^{-\frac{1}{\gamma}} R_{t+1}}. \tag{9}$$

2.3 The government

The government runs a public funded pension system. Within the transfer scheme considered there is a time-lag between the government's income and expenditures. Introducing the time-lag is a technical way to construct a public funded system. This entails that the government can contribute to the national wealth by investing the tax income in productive use, before making the transfers to the retired individuals in the next period. This implies that

$\Theta(\lambda_{t-1})w_{t-1}h_{t-1}(1-\lambda_{t-1}) = R_t\Omega_t$, where Ω is the government's wealth, and given by:

$$\Omega_{t+1} = \tau_t w_t h_t (1-\lambda_t)\,. \tag{10}$$

The government's budget restriction is accordingly:[1]

$$\tau_t w_t h_t (1-\lambda_t) R_{t+1} = \Theta(\lambda_t) w_t h_t (1-\lambda_t)\,, \tag{11}$$

where the RHS is P_{t+1}. Solving the budget restriction for the pension ratio yields:

$$\Theta(\lambda_t) = \tau_t R_{t+1}\,. \tag{12}$$

2.4 Equilibrium dynamics

The model can be solved in terms of the two capital stocks, i.e. optimal choice of human capital and the capital market equilibrium. Optimal study time is determined by the first order condition of (6):

$$\frac{\Theta'(\lambda_t)}{R_{t+1}}\psi(\lambda_t)(1-\lambda_t) = -\psi'(\lambda_t)(1-\lambda_t) - \psi(\lambda_t) = 0\,, \tag{13}$$

where we have inserted the budget restriction in (12). The first order condition in (13) shows that the tradeoff between studying and working is a function of the relation between study time and pensions, and the interest rate. To keep the notation simple, it is convenient to define a function $\mathcal{G}(\cdot)$ as follows:

$$\mathcal{G}(\lambda_t) := \psi'(\lambda_t)(1-\lambda_t) - \psi(\lambda_t) = 0\,. \tag{14}$$

Since $(1-\lambda_t)\psi'(\lambda_t)$ is decreasing in λ_t, and $\psi(\lambda_t)$ is increasing in the interval $(0,1)$, λ_t is uniquely determined and time constant. Inserting the definition of $\mathcal{G}(\lambda_t)$ into (13) gives:

$$\frac{\Theta'(\lambda_t)}{R_{t+1}}\psi(\lambda_t)(1-\lambda_t) = -\mathcal{G}(\lambda_t)\,. \tag{15}$$

Thus, the optimal level of study time in an economy with a public funded pension scheme can be written as a generic function of the interest rate and the pension system:

$$\lambda_t = \lambda(R_{t+1};\, \textit{pension system}) = \lambda^F\,, \tag{16}$$

where λ^F denotes optimal study time in a public funded economy. Thus, the dynamics of the human capital stock follow $h_t = \psi(\lambda^F)h_{t-1}$, and the growth rate in the economy is accordingly given by $\psi^F = \psi(\lambda^F)$.

[1] The budget restriction presented here closely follows Thøgersen (2001).

The next step in the solution is to establish the optimal level of capital intensity. The equilibrium condition in the capital market is given by:

$$K_{t+1} = S_t + \Omega_{t+1} \, . \tag{17}$$

Since the growth rate in the economy is given by $\psi(\lambda_t)$, $H_{t+1} = \psi(\lambda_t)H_t$. Combining this with the definition of capital per efficient unit of labor $K_{t+1} = \kappa_{t+1}H_{t+1}$, we get:

$$K_{t+1} = \kappa_{t+1}\psi(\lambda_t)H_t \, . \tag{18}$$

By inserting (18), the first order conditions in (1), optimal savings (7) and the government's wealth (10) into the equilibrium condition of the capital market, the dynamic equilibrium sequence of capital intensity becomes:

$$\begin{aligned} \kappa_{t+1}\psi(\lambda_t)H_t = & \frac{\omega(\kappa_t)H_t}{1 + (\rho f'(\kappa_{t+1}))^{-\frac{1}{\gamma}} f'(\kappa_{t+1})} \\ & \times \left[1 - \tau_t - \theta(\lambda_t)\left(\rho f'(\kappa_{t+1})\right)^{-\frac{1}{\gamma}}\right] + \tau_t \omega(\kappa_t) H_t \, . \end{aligned} \tag{19}$$

In a Laissez-Faire economy, optimal study time is given by the first order condition of (8):

$$(1 - \lambda_t)\psi'(\lambda_t) - \psi(\lambda_t) = 0 \, , \tag{20}$$

which implicitly defines the optimal length of study time that maximizes life-cycle income in a Laissez-Faire economy λ^{LF}.[2] By the use of the definition in (14), the optimal level of λ^{LF} is characterized by $\mathcal{G}(\lambda^{LF}) = 0$, and the growth rate in the economy is given by $\psi^{LF} = \psi(\lambda^{LF})$, The dynamic equilibrium sequence of capital intensity reduces to:

$$\kappa_{t+1}\psi(\lambda_t)H_t = \frac{\omega(\kappa_t)H_t}{1 + (\rho f'(\kappa_{t+1}))^{-\frac{1}{\gamma}} f'(\kappa_{t+1})} \, . \tag{21}$$

3 Growth in the long-run

In the following we confine the analysis to steady-state growth. This implies $\kappa_t := K_t/H_t = \kappa$, so that the first order conditions in (1) become:

$$R_t = f'(\kappa) = R \quad \text{and} \quad w_t = f(\kappa) - \kappa f'(\kappa) = \omega(\kappa) \, . \tag{22}$$

[2] This tradeoff between studying and working was first studied by Ben-Porath (1967). However, the current set up follows d'Autume and Michel (1994).

Thus, in steady-state, the equilibrium condition in the capital market (19), becomes:

$$\kappa\psi(\lambda^F) = \frac{\omega(\kappa)}{1 + f'(\kappa)(\rho f'(\kappa))^{-\frac{1}{\gamma}}}\,, \tag{23}$$

by the use of (12) and (22). Equation (23) determines the level of optimal capital intensity in a funded system, denoted κ^F. In the remainder of the paper, the following definition turns out to be useful:

$$g(\kappa) := \frac{1}{1 + f'(\kappa)(\rho f'(\kappa))^{-\frac{1}{\gamma}}} \frac{\omega(\kappa)}{\kappa} > 0\,. \tag{24}$$

To show Corollary 1 in the present paper it is necessary to determine the sign of $g'(\kappa)$. It is straightforward to show that the derivative of the first factor in (24) is positive. However, the derivative of $\omega(\kappa)/\omega$ is in general indeterminate. Therefore, we follow Bhattacharya et al. (1997) and assume that for all $\kappa > 0$, $\omega(\kappa)/\omega$ is strictly decreasing.[3] Hence, $g'(\kappa) < 0$. Applying the definition in (24), the steady-state equilibrium in (23) can be written as $\psi(\lambda^F) = g(\kappa^F)$.

We can then establish that in steady-state, optimal study time is determined by:

$$\mathcal{G}(\lambda^F) = -(1-\lambda^F)\psi(\lambda^F)\frac{\Theta'(\lambda^F)}{f'(\kappa)}\,,$$

by the use of (15), and that $\lambda_t = \lambda^F$. Denoting the RHS by $\mathcal{C}(\kappa, \lambda^F) > 0$, the condition simplifies to $\mathcal{G}(\lambda^F) = -\mathcal{C}(\kappa, \lambda^F)$, where $\mathcal{C}'_\kappa(\kappa, \lambda^F) > 0$.

Finally, the system that describes the behavior of λ and κ in an economy with a public funded pension scheme is given by:

$$\mathcal{G}(\lambda^F) = -\mathcal{C}(\kappa^F, \lambda^F) \tag{25}$$

$$\psi(\lambda^F) = g(\kappa^F)\,. \tag{26}$$

The model can thus be solved recursively from the two equations in (25) and (26). First, optimal study time is derived from the first order condition in equation (25), then, the equilibrium level of capital intensity is derived from the equilibrium condition in the capital market (26).

In a steady-state Laissez-Faire economy, the capital market equilibrium in (21) becomes:

$$\kappa\psi(\lambda^{LF}) = \frac{\omega(\kappa)}{1 + f'(\kappa)(\rho f'(\kappa))^{-\frac{1}{\gamma}}}\,, \tag{27}$$

[3]This assumption is elaborated in the appendix.

which determines the equilibrium κ, denoted κ^{LF}. Applying the definition in (24), the condition in (27) can be written as:

$$\psi(\lambda^{LF}) = g(\kappa^{LF})\,. \tag{28}$$

From equation (25), (26) and (28), the following proposition holds.

Proposition 1 *Economic growth is higher in an economy with a public funded pension system, than in a Laissez-Faire economy, i.e.* $\psi^F > \psi^{LF}$.

Proof. The proposition is proved by showing that $\lambda^F > \lambda^{LF}$. The optimality conditions in (25) and (20), reveal that $\mathcal{G}(\lambda^F) < \mathcal{G}(\lambda^{LF})$, as $\mathcal{C}(\kappa^F, \lambda^F) > 0$. Hence, $\lambda^F > \lambda^{LF}$, by $\mathcal{G}'(\lambda) < 0$. Moreover, upon $\psi'(\lambda) > 0$, this implies that $\psi(\lambda^F) > \psi(\lambda^{LF})$, which completes the proof. ■

The result follows as the pension function relating study time and pension payments also applies in the funded system. The incentive for skill acquisition is higher in an economy that subsidizes education through the old-age pension system, than in an economy where such a relation is absent. Therefore, human capital accumulation is higher, triggering higher economic growth. This result is important as it shows that an unfunded pension scheme is not necessary to capture the positive externality in the human capital production function. The same spillover and growth effects can be realized in a properly designed public funded system.[4]

We can now compare capital intensity between the Laissez-Faire economy and the public funded economy.

Corollary 1 *Capital intensity, given by the ratio of physical capital to efficient labor, is higher in a Laissez-Faire economy than in an economy with a public funded pension scheme, i.e.* $\kappa^{LF} > \kappa^F$.

Proof. Proposition (1) shows that $\lambda^F > \lambda^{LF}$, hence $\psi(\lambda^F) > \psi(\lambda^{LF})$. Upon $\psi'(\lambda) > 0$, it follows that the LHS of (26) is greater than the LHS of (28). The same relationship must hold for the RHS of the two conditions, i.e.

$$g(\kappa^F) > g(\kappa^{LF}) \;\Rightarrow\; \kappa^{LF} > \kappa^F\,,$$

[4]It should be mentioned that this analysis result may alter if a more general model is applied. By employing an additive separable utility function the effect of the pension system on savings is ambiguous, hence the derivative of $g(\kappa)$ is ambiguous, despite Assumption 1. Accordingly, the system given by (26) and (28) is impossible to study analytically. Regarding the production function, the neoclassical assumptions include that this function is homogenous of degree one. If we relax this assumption we are not able to write the production function in intensive form the way we do. The system will then increase by one dimension and the dynamic behavior of capital becomes ambiguous.

as $g'(\kappa) < 0$. ∎

The intuition is that a public funded scheme increase the stock of human capital, and thereby leads to lower physical capital relative to human capital.

4 Concluding remarks

This paper examines a novel mechanism between a public funded pension system and economic growth. A classical result is that a funded pension system generates higher economic growth than a PAYG system. However, Kemnitz and Wigger (2000) provide a counterexample of this result and state that economies with a PAYG system can grow faster than economies with a funded pension system. A funded system is in Kemnitz and Wigger equivalent to a Laissez-Faire economy.

In the current paper we study whether a public funded system can deliver higher economic growth than a Laissez-Faire economy. It is shown that the result in Kemnitz and Wigger will also hold for a suitably designed public funded pension system. In this way the present paper provides a counterexample to the counterexample in Kemnitz and Wigger. Accordingly, this paper support their conclusion that the impact of social security on economic growth is an ambiguous issue.

The result that a public funded system will capture the stimulation of skill acquisition, has an important policy implication. Several countries have pension reforms on their policy agenda. The concern is how a reform towards more funded systems will have implications for the economy, and it is thus important to study several aspects of different social security systems. The current paper contributes to the theoretical literature investigating such issues, and aims to fill a gap regarding funded systems and human capital driven growth.

Finally it is necessary to emphasize that the essential message of this paper is to relate social security and economic growth. Welfare issues are left out. However, an important and interesting question is whether the public funded system leads to a Pareto-improvement, compared to both a Laissez-Faire economy and the PAYG system. It would then be necessary to expand the paper with an analysis of intergenerational welfare. Such an issue would be important to address in future research.

Appendix

The sign of the derivative of $\omega(\kappa)/\kappa$ is in general indeterminate. But, it can be shown that the assumptions on the production function imply the following limit condition (de la Croix and Michel, 2002):

$$\lim_{\kappa \to +\infty} \frac{\omega(\kappa)}{\kappa} = 0 \,.$$

Hence, for large κ, $\omega(\kappa)/\kappa$ is necessarily decreasing. But, for small κ, $\omega(\kappa)/\kappa$ can go to any limit, provided that this limit exists. Therefore, we apply the following assumption from Bhattacharya et al. (1997).

Assumption 1 *For all $\kappa > 0$, $\omega(\kappa)/\kappa$ is a strictly decreasing function, i.e. the derivative of $\omega(\kappa)/\kappa$ with respect to κ is negative. Or equivalently, $\kappa\omega'(\kappa)/\omega(\kappa) < 1$.*

Assumption 1 holds, for instance, if the production function is Cobb-Douglas or a CES with an elasticity of substitution greater or equal to one.

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