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Optimal education in times of ageing: The dependency ratio in the Uzawa–Lucas growth model

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ABSTRACT

The increasing share of retirees puts pressure on the shrinking working generation which will need to produce more output per worker to ensure a constant standard of living. We investigate the influence of a changing dependency ratio has on the time individuals spend in education and production. Longer education will increase productivity in the future, but will lower production in the short run, whereas an increase in labour input at the cost of education will provide more production immediately. We introduce a dependency ratio into a discrete-time Uzawa–Lucas model with international capital movements, human capital externalities and decreasing returns to labour in human capital formation. The dependency ratio is defined as the fraction between inactive and active individuals in regard to work or education. By calibration of the model, we find multiple steady states indicated by a u-shaped relation between education time-shares and the growth rate of the dependency ratio. Near the stable, high-level steady state, the optimal response to higher growth of the dependency ratio is more education to enhance productivity. We find evidence for this relation for 16 OECD countries. As a model extension, a debt-dependent interest rate has been introduced and estimated.

Introduction

During the past decades concern has been raised towards the question whether and how the changing age structure in the USA, Europe, China and other countries will change economic behavior. Demographic change is caused by increased longevity on the one hand, and lower birth rates on the other (Lee, 2003). With increased longevity, a higher share of one's lifetime is spent in retirement as long as the retirement age is constant. Lower birth rates cause a decreasing share of population who will later be able to generate output to support the rest of the population. Also, higher life expectancy drives up the dependency ratio independently. This may result in shortcomings in supporting the non-working members of society. Instead of analyzing the cause of demographic change, this paper looks at its effects on economic growth and education. Consequently, demographic change is conceptualized by analyzing the two major consequences of the transition; the increasing number of retirees and the decreasing workforce. One way to measure these dynamics is to look at the dependency ratio and its development. It indicates how many people need to be supported relative to the number of people who are working. This concept will be introduced into an Uzawa–Lucas growth model.

Several studies have supported the pessimistic view of diminishing real output per capita and national savings rates due to population ageing within the next years if there is no impact on technical change (Bloom et al., 2010; Fayissa and Gutema, 2010; Hviding and Mérette, 1998; Muysken and Ziesemer, 2013, 2014). Wright et al. (2014) calculate the loss of per capita output caused by demographic change in absence of technological shifts to be more than 15% within the next 100 years. If the goal is to keep consumption per capita constant or even growing, production per worker needs to increase in order to keep up with the rising number of non-working members of the population. One way to increase production is to keep productivity per worker constant, but increase the time spent in production. The longer the production time, the more output can be generated with a constant productivity, implying a higher retirement age or more working hours per year. Another way is to increase the productivity of each worker and, hence, increase output per working-hour. This way, no extra time in production is needed, but this productivity increase comes at a cost. Workers need more education to learn how to

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produce more productively, indicating a higher time share devoted to education rather than production. The educational optimum is likely to change in times of ageing. Galasso (2008) analyzes the effect of a higher retirement age in several OECD countries, implying a constant educational share. His results are in favor of a higher retirement age, though, he neglects the possibility of a higher output through higher productivity. This paper focuses on the impact of the demographic change on education. The literature on the interaction of the demographic change and schooling is diverse. Through their vintage human capital model with a realistic survival law, Boucekkine et al. (2002) find that an increase in longevity results in longer schooling and a later retirement. The question remains, whether longer schooling is proportionate to the longer life span, or if there is a shift towards a higher or lower share of education. De la Croix and Licandro (1999) show that an increasing life expectancy has a positive effect on the individual time devoted to schooling, but may have a negative effect on participation rates.

We do not deal explicitly with life expectancy, retirement age, fertility, and working hours before retirement. In particular, we are not going to model the past and now regretted errors of pension funds allowing people to retire shortly after having reached age 50. They are included implicitly in the exogenous growth rates of labour and population which we use. Other things constant, an earlier retirement leads to a smaller labour force and a higher dependency ratio. Similarly, living longer without working longer has the same effect on the dependency ratio because population growth is higher because of a lower mortality rate. More children at pre-school age also enhance the dependency ratio. Our formulation of the ratio does not require making all these details explicit as microeconomics studies, demographers and pension funds usually do. Countries differ in all these details because of differences in institutions. We do not go into all the institutional details in the following literature discussion, but this literature points to the importance of institutional aspects regarding health, (public) education, labour (see retirements discussion in the introduction and Section "Empirical analysis" below) and capital markets. Hansen and Lønstrup (2012) show for a utility maximizing household that without student loans and correspondingly less education, an increase in the probability to go to the third period, during which a retirement decision is taken, leads to less of an increase of savings than with student loans and therefore the final period's utility is maximized by earlier rather than later retirement. Cervellati and Sunde (2013) extend this household decision model with a positive death probability in every period and perfect capital markets. In their model, decreasing mortality and reduction of labour time during the working period increase the benefits and reduce the opportunity costs of education. The resulting positive income effect yields more educated people and less labour supply. The latter is inessential for the impact of life expectancy on the share of people that receive schooling at given equilibrium wages, which the authors model using a Mincer equation. Cervellati and Sunde (2015a) add a decision on the hours spent on education to the schooling decision, but hours not spent on education cannot be invested in technical change because the demand side is not needed for the purpose of their paper. In contrast, the problem of ageing is to cause a general equilibrium effect of an increased dependency ratio driving up wages for human capital, and reducing labour demand of producers and providing a stronger incentive, but also leading to larger opportunity costs for a shifting time input into education. In a general equilibrium model by Cervellati and Sunde (2015b) fertility does not feedback into education, and because technical change is a byproduct of education it is not possible to move a factor out of production of output into that of technical change as both are increasing with the share of educated people when the economy is in a developed stage; once all people have education technical change is at a fixed rate. In the models of Cervellati and Sunde (2015a,b) and Bonneuil and Boucekkine (2014) life expectancy has an impact on public education under high life expectancy, low mortality and fertility, but in both no other strategy like capital accumulation under international capital movements, or investing in technical change exists. In the Uzawa–Lucas model, which we use, shifting labour from production of output to that of human capital, identical to technical change, is possible. Decreasing returns to education time in human capital formation and human capital externalities in final output production become crucial. Empirically, the positive effects dominate and education is enhanced. This generates technical change under an infinite horizon including all future generations. Limited life expectancy and mortality appear in our model only implicitly in the form of a positive rate of depreciation of human capital. What matters in the end for all countries' ageing, is the dependency ratio and its growth, unless one is interested in the details of the distribution across a continuum of generations, which is beyond the scope of this paper. As a byproduct of not using life expectancy and fertility, in our empirical parts we do not have to choose between different measures of life expectancy (age 5 or at birth) and mortality (adult, maternal, at working age, under 5, or infant), which have theoretically ambiguous and empirically controversial effects (Hazan, 2012).[1]

Therefore, in this paper a dependency ratio, defined as the population/labour ratio without the explicit modeling of the underlying age distribution, is introduced into a discrete-time Uzawa–Lucas model (Frenkel et al., 1996; Lucas, 1988; Uzawa, 1965) with capital movements, decreasing returns to labour in human capital formation, and human capital externalities in final output production to find out how the economy reacts to the new challenges. We find two optimal shares of education. In the lower steady state, the economy faces high participation rates in production with relatively little time in education, whereas the other steady state is characterized by high schooling. The latter one is stable. We are specifically interested in the optimal share of education and its implied effects on the economy, in particular its level and growth of productivity. A virtuous circle of education and productivity in connection with favorable demographic trends is most popular in the literature explaining the escape from per-industrial low income and growth. For example in the model of Becker et al. (1994) a human capital shock leads to lower fertility and a lower discount rate per child but a higher discount rate for all children together, which induces a reduction of a high number of children in favor of more education for each child, leading to more growth and less fertility again. Similarly, in the model by Cervellati and Sunde (2005) an improvement in life expectancy encourages human capital formation, which increases technical progress, which in turn encourages more human capital formation. In contrast, in our model for rich countries an unfavorable development of ageing triggers an increase in education and productivity.

The paper is structured as follows: In Section "The model" the model will be set up. Section "Existence and partial stability of multiple steady states" analyzes the existence and stability of multiple steady states. Section "Empirical analysis" will introduce the data for the dependency ratio and the share in education, and shows the relation between the model and the data. Section "Debt dynamics and general equilibrium" addresses the dynamics of foreign debt and Section "Conclusion" concludes.

[1] The complications stem from the diverse causes of the change in life expectancy. Hansen (2013) suggests that in regression analysis of the effect of life expectancy on schooling life expectancy should be instrumented by its causes, medical innovations related to childhood diseases (Hansen 2013); Cervellati and Sunde (2013) emphasize the shifting peak towards higher age of the survival distribution during working age.