

Health, Endogenous Fertility and Economic Growth

by

Ole Hagen Jørgensen

Discussion Papers on Business and Economics
No. 2/2008

FURTHER INFORMATION
Department of Business and Economics
Faculty of Social Sciences
University of Southern Denmark
Campusvej 55
DK-5230 Odense M
Denmark

Tel.: +45 6550 3271
Fax: +45 6550 3237
E-mail: lho@sam.sdu.dk
<http://www.sdu.dk/osbec>

ISBN 978-87-91657-17-7

HEALTH, ENDOGENOUS FERTILITY AND ECONOMIC GROWTH*

Ole Hagen Jørgensen[†]

Centre for Economic and Business Research, and
University of Southern Denmark

January 29, 2008

Abstract

This paper shows how improved health conditions affect fertility decisions and economic growth. Survival rates for children and adults are incorporated into an overlapping generations model featuring endogenous fertility and altruism from workers towards their retired parents. The main finding is that a simultaneous increase in child and adult survival decreases fertility and increases savings and productivity growth. The analysis illustrates the key role of health in the demographic transition.

JEL Classification: H55, I18, J13, O11, O16, O41.

Keywords: Health, mortality, endogenous fertility, demographic transition, endogenous economic growth.

*I am especially grateful to Jocelyn Finlay for excellent comments and valuable discussions. Furthermore, I thank Svend E. Hougaard Jensen, Dino Merotto, John May, Oded Galor and David Canning for helpful comments. A technical appendix accompanies this paper and is available upon request.

[†]Ole Hagen Jørgensen: OJ@cebr.dk, www.cebr.dk/oj, address: University of Southern Denmark, Department of Business and Economics, Campusvej 55, 5230 Odense M, Denmark.

1 Introduction

Most countries have seen child and adult survival rates increase during the first stage of their demographic transition. This is usually followed by a decline in fertility in the second stage and, thus, strongly decreasing dependency ratios. As a result, the demographic transition provides a window of opportunity for economic growth by releasing resources for savings and human capital formation. According to Bloom and Williamson (1998) approximately one-third of the increase in economic growth for the East-Asian "tigers" can be explained by purely demographic factors, i.e. the declines in mortality and fertility. This demographic "dividend" therefore entails a real chance to reduce poverty.

In this paper, we consider an increase in survival rates for children, as well as for adults, and trace the effects to fertility decisions, savings, and economic growth. Our aim is, first, to identify the key mechanisms that bring countries from the first to the second stage of the demographic transition, and second, to investigate how health and pension policies can be designed to promote this process by providing stronger incentives for having fewer children. While existing literature only studies changes in adult survival as a proxy for life expectancy, this paper separates the effects from higher child survival and adult survival, respectively. Thereby, we can isolate the unique effects from each survival rate on savings, fertility and economic growth. To our knowledge this has not been attempted before.

Capital saving is a key variable to focus on in the demographic transition of an economy to sustained economic growth. Increased savings will produce a higher capital-labour ratio and, in line with standard growth theory, also the potential for per capita economic growth. According to Chakraborty (2004), higher adult survival rates (modelled as a higher life expectancy) will increase the capital stock and per capita economic growth. The reason is that savings increase when people expect a longer retirement period to be financed by savings¹. As a consequence, the increase in savings is the key determinant for growth in a framework with exogenous fertility and without the care by workers for the subsistence of their retired parents. However, in developing countries, children can also be considered a form of savings because they tend to care for their parents in old age, i.e. the higher number of children per household the more altruistic transfers can be expected in old age (Ehrlich and Lui, 1991).

In order to trace the effects on savings, these issues should be accounted for in the analytical framework. We accomplish this by endogenising fertility and altruistic intergenerational transfers. If more children survive into working age or more workers survive into retirement, there may be consequences for the choice of the number of children and the intertemporal allocation of consumption. As a result, the net effect on savings may not necessarily be an increase, because workers may choose to "save" through having more children, and in turn dissave by reducing their capital savings. The result in Chakraborty (2004), i.e. that improved health conditions will make life expectancy rise and thus increase capital savings and economic growth, may therefore not hold when the economy

¹In Chakraborty's model, investments in health increase proportionally to the increasing income, which in turn leads to a longer life span, so the economy enters a positive spiral of better health, longer lives, more capital savings, and higher per capita income.

is modelled in accordance with the features of developing countries.

In addition to our personal joy of having children, to which we seem to be more or less genetically programmed (Dasgupta, 1993; p. 356), the motivation for having children can be considered an economic one. Children can provide labour that will benefit the household; they can provide care for parents in old age; and they may be an instrument of altruism from parent to child (Barro and Becker, 1989). Another motivation for having children is the expectation of receiving altruistic intergenerational gifts (transfers) from one's children after retirement (Wigger, 2002; Ehrlich and Lui, 1991). Higher capital savings would substitute this intergenerational gift to the effect of lowering the gift rate and further reducing the need for having children as an old age security device.

The choice of how many children to have is, to a large extent, a function of child survival (Pritchett, 1994; Barro and Becker, 1989) and of access to family planning (Bongaarts, 1990, 1994). Families plan to have their desired number of (live) children, and in an environment of high child mortality the differential between the number of desired children and births widens (Fink, 2007). As the child survival rate improves, families need fewer births to achieve their desired number of children.

Concurrent with the child survival response, parents also face the quality/quantity trade-off (Galor and Weil, 1996, 2000). With a fixed amount of resources available to devote to the children of the household, parents make the decision to have many children and invest little in each, or have few children and invest more in each. The incentive for the latter will grow as the return to human capital increases parallel to technological development. In this paper, we abstract from human capital investments since the effects thereof are well established.

Improved adult health (proxied in the literature by higher life expectancy) is generally found to have increasing effects on economic growth per capita, see e.g. Chakraborty (2004); Jensen and Jørgensen (2008); Jørgensen (2008); Bloom, Canning, Mansfield, and Moore (2007). In the presence of perfect capital markets and no social security arrangement, we would envision longer life expectancy to have no effect on the savings rate as the extension of working life is proportional to the extension of life expectancy but that the aggregate savings level increases. However, in the presence of social security arrangements where the retirement age is fixed, an increase in life expectancy increases the years of retirement disproportionately to the working years. This is a case where the intertemporal prices of consumption in the first relative to the second period change, and if they do not change in equal proportions then the savings rate will change (Jensen and Jørgensen, 2008; Jørgensen, 2008; Chang, 1990). The retirement age could be adjusted to offset this effect (Jensen and Jørgensen, 2008; Jørgensen, 2008).

Bloom, Canning, and Moore (2005) show, however, that this life-cycle savings model is incomplete, and that an increase in life expectancy can actually have a negative effect on the savings rate. They argue that if the retirement age is endogenously determined, then a rise in life expectancy leads to a less than proportional rise in the retirement age so savings decline. This result is driven by a wealth effect of the longer working life. Jørgensen (2008) finds a similar result in a model with endogenous labour supply, where the wealth effect, due to distortionary taxation, more than outweighs the sum of substitution and income effects when life

expectancy increases.

Higher adult survival can also have incentive effects that may be important for capital savings: investments in human capital will be encouraged as the time horizon over which returns to investment can be earned is extended (Weil, 2007; Finlay, 2006). Adult survival may also represent a proxy for experience: the longer one is alive the larger the work experience. Although this theory is dispelled by Bloom, Canning, and Sevilla (2004), who control for labour market experience, they found that increased adult survival had a positive effect on savings and economic growth. Alternatively, if adult survival is considered a proxy for health, then better health can lead to higher worker productivity and promote economic growth (Barro and Lee, 1994; Finlay, 2006; Bloom, Canning, and Sevilla, 2004; Zhang and Zhang, 2005).

The economic implications of changes in *child survival*, on the other hand, has only been explored to a much smaller extent in the theoretical literature. To account for this shortcoming, this paper illustrates a channel of dynamics that can unfold, in which the motivation for having children will shape the resource allocation. If fertility is endogenous, such that fertility falls with the increase in child survival, we would expect little change in savings as the unchanged resources are now devoted to a smaller number of children consistent with the quality/quantity payoff (Galor and Weil, 1996, 2000). Alternatively, with fewer children, and without human capital accumulation, more resources could potentially be devoted to (non-child) consumption or savings. The latter argument is implied by the model in this paper.

Having explored the theoretical benefits of improved survival rates, we then take this a step further and ask: Can economic policy be targeted at health and public pensions in order to provide incentives for having fewer children, and could this fertility decline potentially promote higher per capita economic growth? Assuming that better health is the cause of increasing survival rates, we trace increases in both the child survival rate and the adult survival rate to their impacts upon fertility, savings and economic growth, respectively. We next consider how pensions can potentially reduce the need for children as an old age security device and through these dynamics increase capital savings and economic growth. This issue was also addressed by Wigger (2002), but he does not incorporate survival rates into his model and is therefore not in a position to study the demographic transition and the economic implications it entails.

The paper is structured as follows: in section 2 we outline the model, and section 3 solves for the competitive equilibrium. We then conduct comparative statics in section 4, where we impose exogenous increases in, first, child survival and then adult survival. We next perform the experiment with a *composite* increase in child and adult survival. These simulations trace the long run effects of such demographic changes to savings, fertility and economic growth. Finally, section 5 discusses some model limitations and provides suggestions for future research. Furthermore, we provide perspectives on the potential of public pensions to promote the dynamics of the demographic transition. Section 6 concludes.

2 The Model

The overlapping generations (OLG) model is outlined in this section. We owe the basic structure of the model to Wigger (2002), who incorporates altruism and endogenous fertility decisions into an OLG model *ad modum* Diamond (1965), which leads to an old age security motive for having children. Our model extends this structure by incorporating child and adult survival rates, respectively. We assume that improved health conditions generates higher survival rates². We follow Jørgensen (2008) in the incorporation of the survival rates, in order to analyse their impact on savings, fertility and economic growth.

2.1 Demographics

Individuals are assumed to live for three periods: as children, as working age adults, and as retired adults (see figure 1). Parents are assumed to make economic decisions on behalf of their children. The *child survival rate*, $0 < \mu_1 \leq 1$, is assumed to denote the survival of children immediately before they enter the labour force as adult workers. In that way, a higher μ_1 translates into a larger labour force. A higher *adult survival rate*, $0 < \mu_2 \leq 1$, on the other hand, is incorporated such that more workers survive into retirement. Labour is inelastically supplied by workers, N_t , and is assumed to grow by $1 + n_{t-1} = N_t/(\mu_1 N_{t-1})$, where $n > -1$ is the growth rate. If child survival or fertility increases then the labour force will grow at a higher rate.

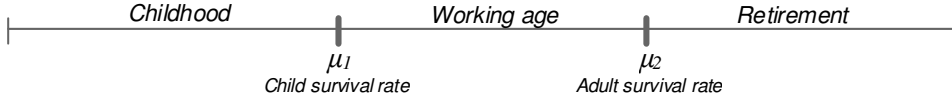


Figure 1. Child and adult survival rates

2.2 Budget constraints

Workers earn wages, w_t , and choose savings, S_t , in accordance with (1).

$$S_t = [1 - z_t - \kappa(1 + n_t) - \theta] w_t - \mu_1 c_{1t} \quad (1)$$

However, different costs must be serviced by workers: first, there exists a pay-as-you-go (PAYG) pension system with a contribution rate, θ ³. Secondly, the cost of raising $(1 + n_t)$ number of children is denoted by κw_t , where κ is the share of income that covers the costs per child. Consequently, if either the number of children per household increases, if the cost of rearing a child increases, or if pension contributions increase, there will be less income available for first period consumption, c_{1t} , and savings.

²We do not, however, incorporate a government health sector or private investments in health. Higher health investments would otherwise be expected to increase survival rates in line with Chakraborty (2004), but since we are interested in a closed form solution for key variables, which Chakraborty does not provide, a framework with endogenous health expenditure that endogenously affects survival rates will remain an issue for our future research.

³We assume a very small contribution rate in line with the features of pension schemes in developing economies.

Workers are assumed to be altruistic towards the subsistence of their retired parents, to whom they have the option of transferring income (gifts). If, however, retirees already have enough consumption, and thus adequate utility, workers will reduce the gift rate, z_t , to whichever level their degree of altruism supports. Second period consumption, c_{2t+1} , is determined by last period's savings that pays a gross return of $R_t = 1 + r_t$, see (2).

$$c_{2t+1} = \frac{R_{t+1}}{\mu_2} S_t + [(1 + n_t) z_{t+1} + \lambda_{t+1}] w_{t+1} \quad (2)$$

An increase in μ_2 would force more retired members of the household to spend their savings at a lower rate, $1/\mu_2$. Retirees may receive altruistic transfers from their working age children, depending on the number of children they have and the wage rate. Consequently, the more children you have to support you in old age, the more you will probably receive in altruistic gifts. An additional child will provide you with more intergenerational gifts in old age, but you also have to support them whilst working implying less consumption and capital savings. The trade-off therefore (also) depends upon the fact that children possess the same degree of altruism as you, so that you can be certain to receive in old age what you expected when deciding on your number of children⁴.

Finally, retirees receive *variable* pension benefits in accordance with (3),

$$\lambda_t \mu_2 N_{t-1} w_t = \theta N_t w_t \quad (3)$$

where the fixed contribution rate is scaled by the relative survival rates in (4).

$$\lambda_t = \theta \frac{\mu_1}{\mu_2} (1 + n_{t-1}) \quad (4)$$

In case retirees face a higher survival rate, they are forced to spend their benefits at a lower rate. When children, on the other hand, face a higher survival rate, the labour force increases and more workers will pay fixed contributions to the PAYG system. This will allow their retired parents to spend pension benefits at a higher rate. Equivalently, if workers decide to have more children, they can expect higher pension benefits in old age, because fertility is endogenous to the household⁵.

2.3 Household behaviour

The utility of individuals is assumed to, first, be composed by c_{1t} and c_{2t+1} , where $\rho > -1$ is the discount rate (see 5).

$$u_t = \mu_1 [\ln c_{1t} + \phi \ln (1 + n_t)] + \mu_2 \rho \ln c_{2t+1} \quad (5)$$

⁴This is in principle a game-theoretic issue as analysed by e.g. Zhang and Nishimura (1993) and Nishimura and Zhang (1995). We assume in this paper that all generations are altruistic to the same degree.

⁵The PAYG system does not necessarily need to be characterised by fixed *contributions*. It could also be a fixed *benefits* system, where the contribution rate is flexible. The PAYG system would then be re-stated as: $\theta_t = \lambda \frac{\mu_2}{\mu_1} (1 + n_{t-1})$. This would imply that if workers had more children, or if the child mortality rate increased, they would not receive more in pension benefits anyway, since the rate, λ , would be fixed. Therefore, there would be no need to have more children for that reason, so fertility might fall. This is an issue for our future research.

Secondly, workers are assumed to be "genetically programmed" to like children (Dasgupta, 1993, p. 356), and consequently value children, where $\phi > 0$ is the weight on children in utility. Children are therefore (also) considered to be "consumption equivalent" goods. The idea to incorporate survival rates into the utility function is inspired by Jørgensen (2008), such that if μ_1 (μ_2) increases, more workers (retirees) will survive to enjoy consumption and children.

The altruistic element in utility is captured by (6),

$$U_t = u_t + \chi u_{t-1} \quad (6)$$

where χ measures the degree of altruism from workers towards their retired parents, by weighting your parents' utility relative to your own. Thus, the more χ increases the more you care about your parents' subsistence. The number of children is therefore determined by two fertility motives: the "genetic motive" and the "savings motive", where the former is incorporated in the positive effect of children in utility, while the latter arises because parents are assumed to be certain that their children will support them in old age⁶.

2.4 Technology

The macroeconomic framework is based on Wigger (2002) and assumes the endogenous growth set-up inspired by Arrow (1962) and Romer (1986). Identical firms are assumed to employ labour and capital, K_t , in order to produce output, Y_t , in accordance with a standard production: $Y_t = F(K_t, A_t N_t)$, which is assumed to have constant returns to scale. Labour productivity is denoted by A_t , which is endogenised by assuming a linear relationship between productivity and capital per worker due to a positive spillover from investments on productivity in (7).

$$A_t = \frac{1}{\alpha} \frac{K_t}{N_t} \quad (7)$$

This means that $f(k_t) \equiv F(k_t, 1)$, and that the capital stock in efficiency units is $k_t = K_t / (A_t N_t)$, such that the interest rate is

$$r_t = f'(k_t) = f'(\alpha) = r \quad (8)$$

and the wage rate is $w_t = A_t [f(k_t) - k_t f'(k_t)]$. The Arrow-Romer approach in (7) implies that the interest rate is constant, and that the wage rate is determined by

$$w_t = A_t [f(\alpha) - f'(\alpha)\alpha] = \omega \frac{K_t}{N_t} \quad (9)$$

where $\alpha > 0$ is a positive technology parameter, and where $\omega = [f(\alpha) - f'(\alpha)\alpha]/\alpha$ is the "external return" on capital caused by the spillover of cumulated investment upon labour productivity (see Wigger, 2002). Consequently, if N_t rises the capital-labour ratio will fall and the economy-wide level of technology will decrease: then A_t falls and k_t will remain constant. Productivity growth is linked to the growth in the wage rate in (10),

$$1 + g_t = \frac{w_{t+1}}{w_t} = \left(\frac{K_{t+1}}{K_t} \right) \left(\frac{N_t}{N_{t+1}} \right) \quad (10)$$

⁶In terms of both *voluntary* intergenerational gifts and *statutory* fixed pension contributions.

and is determined by the growth in endogenous production factors. The capital market equilibrium condition in (11) completes our model.

$$K_{t+1} = N_t S_t \quad (11)$$

3 The competitive equilibrium

In this section we derive and interpret the first order conditions of the individual optimization problem. We furthermore transform the model into a reduced form system of equations, in terms of the variables we are interested in, which fully describes the dynamic path of the economy. Our results are similar to those of Wigger (2002), on which we build our formal analysis, but all expressions are now adjusted for the child and adult survival rates. To our knowledge, this extension is unique.

Individuals face the following optimisation problem in (12) where aggregate utility is maximised subject to the intertemporal budget constraint (13):

$$\max U_t = \mu_1 [\ln c_{1t} + \phi \ln(1 + n_t)] + \mu_2 \rho \ln c_{2t+1} + \chi \rho \mu_2 \ln c_{2t} \quad (12)$$

$$\text{s.t. } \mu_1 c_{1t} + \frac{\mu_2}{R_{t+1}} c_{2t+1} + (\kappa w_t - \frac{\mu_2}{R_{t+1}} z_{t+1} w_{t+1}) (1 + n_t) = (1 - z_t - \theta) w_t + \frac{\mu_2}{R_{t+1}} \lambda_{t+1} \quad (13)$$

Assuming an internal solution the first order conditions hold with equality. The first optimality condition, given by

$$\frac{c_{2t+1}}{c_{1t}} = \rho R_{t+1} \quad (14)$$

is the Euler equation that optimally allocates first and second period consumption intertemporally. The second optimality condition is more complicated:

$$u_{1t} \phi w_t = u_{2t} z_{t+1} w_{t+1} + u_{3t} \quad (15)$$

The fraction $u_{1t} \phi w_t$ in (15) determines the opportunity cost of having an additional child, measured in terms of the marginal value of the lost first period consumption. The right-hand side shows the sum of two components: the marginal value of the gifts that current workers will receive from their children in the next period, and the marginal value of having another child. Altogether (15) shows the benefits and losses of having another child in terms of marginal utilities (u_{1t} , u_{2t} , and u_{3t}). By substituting these, we find a positive correlation between fertility and first period consumption in (16),

$$\frac{\mu_1 \phi w_t}{c_{1t}} = \frac{\mu_2 z_{t+1} w_{t+1} \rho}{c_{2t+1}} + \frac{\mu_1 \phi}{(1 + n_t)} \quad (16)$$

and thus an inverse relationship between fertility and savings. The third optimality condition (17) describes your trade-off between consuming an additional unit yourself and transferring that unit for your parents to consume⁷. A higher degree

⁷The third optimality condition in (17) is derived by lagging c_{2t+1} to be c_{2t} and subsequently combining the resulting expression with IBC in (13) over $z_t w_t$.

of altruism, χ , and a larger adult survival rate (an increase in μ_2) induce workers to value their parents' marginal utility of consumption to a greater extent. If you have many siblings ($1 + n_{t-1}$ is large) who cooperate in supporting your parents, less of your income is needed to support them, and they consequently become "cheaper" to care for. This means that the "price" of supporting your parents goes down, and you choose to shift consumption from yourself to your parents.

$$\frac{c_{2t}}{c_{1t}} = \mu_2 \rho \chi (1 + n_{t-1}) \quad (17)$$

In this paper we are mainly interested in interpreting the effects of changes in survival rates on the variables: fertility n , productivity growth g , the savings rate s , and altruistic gifts z . The Arrow-Romer production structure allows us to derive the savings rate from the capital market side of the economy and not, as is usually the procedure, from the agent's optimisation problem. By combining the capital market equilibrium (11) with (7) we find the savings rate in (18),

$$s_t = (1 + g_t) (1 + n_t) \frac{\mu_1}{\omega} \quad (18)$$

where both g_t and n_t are endogenous variables. For developing countries we would be interested in seeing an increase in capital savings. The direct positive effect on the savings rate of a change in child survival is evident from (18), but the net effects on the savings level will become clear in our later derivations in general equilibrium. We therefore solve the model by reducing it to a system of equations in the variables g , n and z .

To obtain the reduced form of the model, substitute into the optimality conditions (14) through (17) the constraints (1) and (2), factor prices (8) and (9), the pension benefit rate (4) and finally the capital market equilibrium condition in (11). Note, that the resulting expressions in (19), (20) and (21) incorporate the child and adult survival rates.

$$\begin{aligned} \frac{\rho}{\mu_1} (1 + r) [(1 - z_t - \kappa (1 + n_t) - \theta) \omega - (1 + n_t) \mu_1 (1 + g_t)] = \quad (19) \\ \left[\frac{\mu_1}{\mu_2} (1 + r) + \left(z_{t+1} + \theta \frac{\mu_1}{\mu_2} \right) \omega \right] (1 + n_t) (1 + g_t) \end{aligned}$$

$$\begin{aligned} \rho (1 + n_t) \theta (1 + r) \omega - \frac{\mu_2}{\mu_1} \rho z_{t+1} \omega (1 + n_t) (1 + g_t) = \quad (20) \\ \frac{1}{\mu_2} \phi \left[(1 + r) \mu_1 + (z_{t+1} + \theta) \omega \frac{\mu_1}{\mu_2} \right] (1 + n_t) (1 + g_t) \end{aligned}$$

$$\begin{aligned} \frac{\mu_1}{\mu_2} (1 + r) + \left(z_t + \theta \frac{\mu_1}{\mu_2} \right) \omega = \quad (21) \\ \frac{\mu_2}{\mu_1} \chi \rho [(1 - z_t - \theta (1 + n_t) - \theta) \omega - (1 + n_t) \mu_1 (1 + g_t)] \end{aligned}$$

This procedure has defined the competitive equilibrium as a sequence of only $\{n_t, g_t, z_t\}_{t=0}^{\infty}$: fertility, productivity growth, and altruistic gifts. It is our aim in the following section to analyse the effects of the higher survival rates on these three key variables.

4 Comparative statics

The aim of this section is to employ the analytical framework above to study the effects of higher survival rates on fertility, productivity growth and altruistic intergenerational gifts. We do, however, need to derive a closed form solution for those variables.

4.1 Fertility, productivity growth and altruistic gifts

To derive a closed form solution for the three key variables (z , g and n) in order to perform comparative statics on the balanced growth path, we employ the steady state versions of (19), (20) and (21)⁸. It is clear that the survival rates (μ_1 and μ_2) affect their steady state paths⁹. The expressions are identical to those in Wigger (2002), with the exception that ours are adjusted for the child and adult survival rates, respectively:

$$z(\mu_1, \mu_2) = \frac{(1 - \theta) \chi \omega \rho \frac{\mu_2}{\mu_1} - \left(\frac{\mu_1}{\mu_2} + \frac{\phi}{\mu_1} + \rho \right) (1 + r) - \omega \theta (\phi + \mu_1 \mu_2)}{\left(1 + \rho (1 + \chi) \frac{\mu_2}{\mu_1} + \phi \frac{1}{\mu_2^2} \right) \omega} \quad (22)$$

$$g(\mu_1, \mu_2) = \frac{(1 + r) \rho \omega \kappa \mu_2}{\phi (1 + r) \mu_1 + \omega \phi \theta \frac{\mu_1}{\mu_2} + \omega \left(\rho \frac{\mu_2^2}{\mu_1} + \phi \frac{\mu_1}{\mu_2} \right) z(\mu_1, \mu_2)} - 1 \quad (23)$$

$$n(\mu_1, \mu_2) = \frac{\left(1 + r + \omega \theta \frac{1}{\mu_2} \right) \phi \mu_1}{\chi \rho \omega \kappa \mu_2^2} + \frac{\left(\frac{\mu_2^2}{\mu_1} \rho + \phi \frac{\mu_1}{\mu_2} \right)}{\chi \rho \kappa \mu_2^2} z(\mu_1, \mu_2) - 1 \quad (24)$$

The purpose of the following three subsections is to interpret these relationships, both theoretically and numerically. The aim is then to employ them in policy reflections on savings, fertility and economic growth. This involves calibrating the model using what we believe are realistic parameter values in table 1.

PARAMETER	CALIBRATION	INTERPRETATION
χ	0.9	Degree of altruism
μ_1	1	Child survival rate
μ_2	1	Adult survival rate
ϕ	0.8	Consumption discount rate
η	0.4	Weight on children in utility
r	4	Interest rate
θ	0.1	PAYG contribution rate
κ	0.1	Cost of rearing one child
ω	30	External return on capital

Table 1. Calibration of the model

⁸To obtain the steady state version of (21), divide (19) by (21) such that the resulting expression, $\chi \mu_2 (1 + n)(1 + g) = (1 + r)$, relates the return to savings to the economy's growth factor in steady state, $(1 + n)(1 + g)$, scaled by the degree of altruism and the adult survival rate.

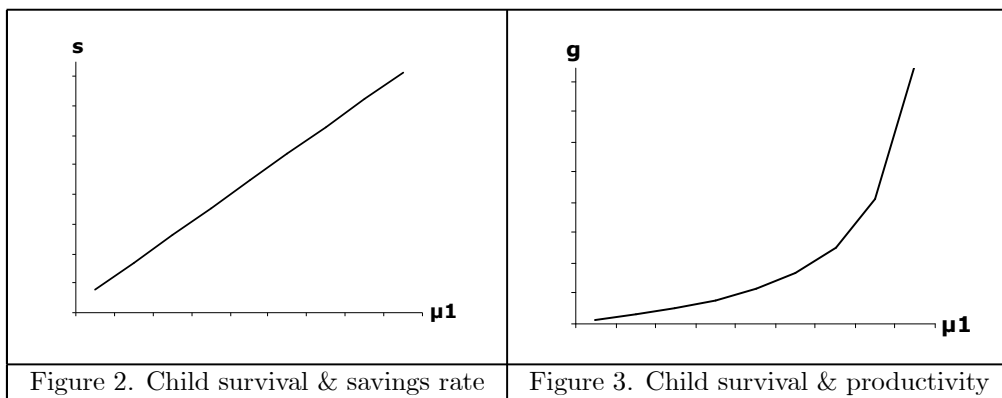
⁹To derive g in (22), insert the steady state version of (20) and (21) into the steady state version of (19) and isolate z . The productivity growth rate, g , in (23) is found by isolating g in the steady state version of (19). By combining (23) with the steady state version of (21) we arrive at the expression for fertility in (24).

We initially calibrate the child and adult survival rates by $\mu_1 = 1$ and $\mu_2 = 1$, but in our simulations we conduct experiments with increases in these rates¹⁰. In section 4.2 we study increases in only the child survival rate, while in section 4.3 only the adult survival rate is assumed to increase. Ultimately, we study the composite increase in both survival rates in section 4.4.

4.2 Child health

In this section we simulate the impact of an increase in the child survival rate, μ_1 , on four variables: the productivity growth rate, g , the fertility rate, n , the altruistic gift rate, z , and the savings rate, s . The impact on these four variables is illustrated in figures 2 through 5.

We identify three key effects that govern the dynamics of the model when μ_1 increases: first, when more members of the household survive, consumption must also be divided among those additional members. This yields less individual first period consumption, and consequently renders second period consumption more attractive in comparison. Equivalently, the relative price of first to second period consumption increases at the same rate as μ_1 increases (see the IBC in (13)). Therefore, the savings rate in (18) increases proportionally to the increase in μ_1 (see figure 2).



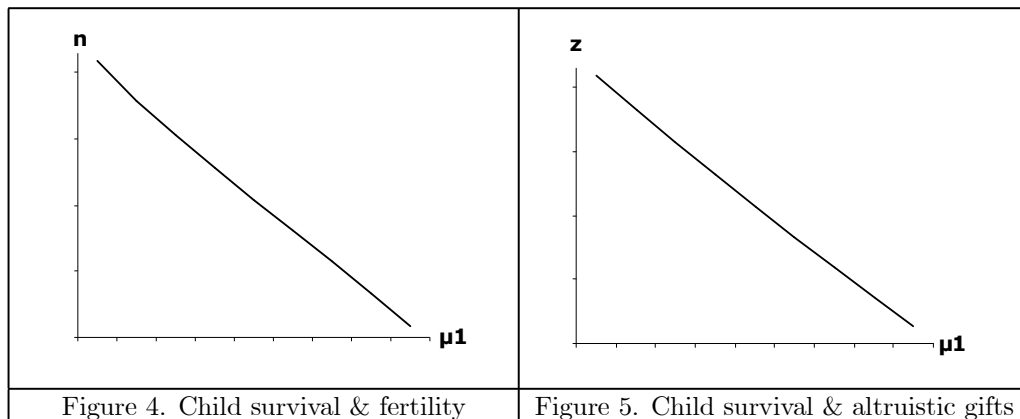
Second, the costs of using children as an indirect savings mechanism (rather than saving through capital investments) will increase because the savings rate and thus wages and productivity increase. This makes children more expensive to rear, and thus less attractive as an old age savings mechanism, given the constant return on capital savings, in accordance with (8).

Third, individuals gain higher utility in their working period by surviving at a higher rate. This increases the marginal utility for first period consumption so savings fall. These three key effects yield an ambiguous net result on savings, but our simulations show that the two positive effects clearly outweigh the single negative effect.

A larger steady state capital stock generates knowledge spillovers and increases labour productivity in figure 3, in accordance with (10). There is an offsetting effect of this result, however, because the size of the labour force also increases

¹⁰A Matlab routine for these simulations is available upon request.

when more children survive into the working age. This reduces, but does not dominate, the effect on wages and the productivity growth rate.



Since it is costly to rear children for the purpose of providing for old age consumption, the need for children falls when savings, and thus second period income, increase. This exerts downward pressure on fertility, $(1 + n)$, as illustrated in figure 4. For the same reason the altruistic gift rate also decreases in figure 5.

There are consequently feedback mechanisms through savings and fertility: the more μ_1 increases, the more the savings rate and productivity growth will increase, and the more fertility and altruistic gifts decrease. When fertility falls, more resources are released for consumption and savings, so the capital stock increases and further enhances productivity growth.

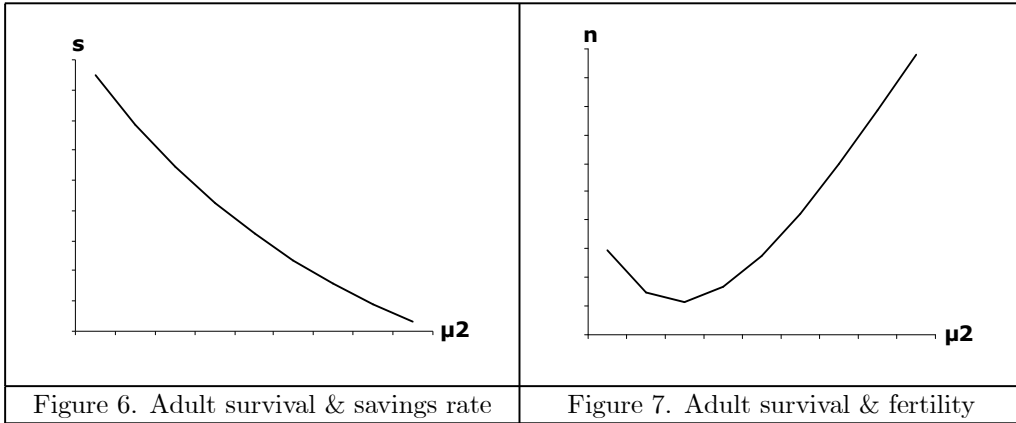
An additional mechanism through which second period income increases is the PAYG system. In accordance with (4), the more μ_1 increases, the higher will be the number of workers who pay *fixed* pension contributions – leading to higher benefits per retiree. This increases second period income, and reduces the need for costly children, so there is a downward pressure on altruistic transfers. However, in the case where pension contributions are fixed, current workers know that the more children they have, the higher will be the number of future workers to pay fixed contributions to them – generating more retirement benefits.

This effect from a fixed *benefits* PAYG system is an additional element that causes high fertility, but even though a system with fixed contributions is included in Wigger (2002), Wigger does not analyse this link, and so misses the importance of the incentives for high fertility caused by the fixed contributions – and the potential gains of switching regime to a fixed benefits PAYG system¹¹.

¹¹The latter argument implies that, no matter how many children workers have, the old age pension benefits will remain the same. Incorporating such a system will lead to two important effects: first, the fertility-incentive of pension benefits is removed so fertility (and therefore also altruistic gifts) can be expected to fall and productivity growth can be expected to increase. Second, if workers need less children to finance old age consumption, they will finance this through the other available channel: capital savings. More savings lead to a higher capital stock and a higher productivity growth rate. These dynamics can be elaborated on analytically by reformulating the PAYG system in terms of fixed benefits, but this is outside the scope of this paper to consider.

4.3 Adult health

This section provides the other leg of interpreting health improvements in the demographic transition by analysing an increase in *adult* survival. There is again an effect on the savings rate originating from the intertemporal price structure of consumption: the prices are seen to depend directly on μ_1 and μ_2 in the intertemporal budget constraint (13). Consequently, when their ratio changes so will the optimal intertemporal smoothing of resources for consumption, i.e. the savings rate. As such, the increasing price (μ_2/R) on second period consumption produces a decline in the savings rate (see figure 6). A counteracting effect is present when μ_2 increases, however, because the marginal utility of second period consumption increases, exerting upward pressure on savings¹².



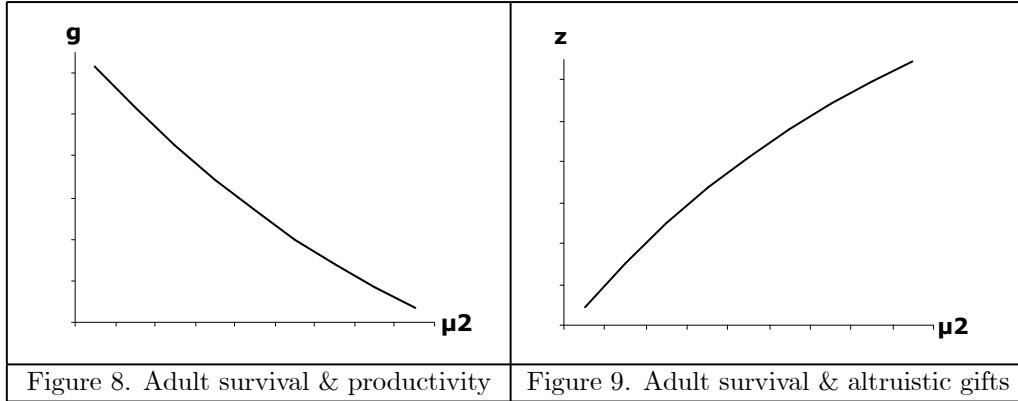
The net impact upon fertility when μ_2 increases is illustrated in figure 7. The increase in the price on second period consumption automatically reduces the relative prices on first period consumption and children, $(\kappa w_t - z_{t+1} w_{t+1} \mu_2 / R_{t+1})$, which increases the fertility rate. When the increase in μ_2 is small, fertility will initially fall, and then increase exponentially the larger μ_2 is. This occurs because of the quadratic terms in μ_2 in $n(\mu_1, \mu_2)$ in (24). Since the savings rate initially fell, the wage rate will also fall, providing households with less income for all types of goods: c_1 , c_2 and $(1+n)$. This will initially reduce fertility, but the more μ_2 increases the less income is available in old age and the insurance motive for having children exerts upward pressure on altruistic gifts and thus fertility. As a strategy to finance old age consumption, workers therefore increase fertility because children now become relatively cheaper than capital savings.

A magnifying impact on fertility and savings originates from the PAYG system. Since workers pay a *fixed* contribution rate and children are now relatively cheaper as a savings mechanism for old age consumption, workers increase the fertility rate in order to have more children paying these fixed contributions. There is a counteracting effect on pension benefits, though. There will be more retirees per household, for any given number of children, and this will generate less benefits to be distributed among retirees. The net effect on benefits is ambiguous, but the

¹²This is the most well-known effect on savings, which is analogous to the result from the literature on ageing, where workers save more to finance a longer retirement period (see Jensen and Jørgensen, 2008; Jørgensen, 2008; Chakraborty, 2004; and Finlay, 2006).

effect on fertility, to at least keep benefits unchanged, is clearly positive. The net effect on fertility becomes positive and increasing in the size of μ_2 .

Since the net effect on savings is negative, the productivity externality on the wage rate diminishes, and consequently productivity growth will decrease (figure 8). The fall in second period income, due on lower gross returns to the declining capital stock, will render altruistic gifts relatively more important as a means of financing old age consumption. As a result, the gift rate in figure 9 increases.



Increases in, for instance, government health spendings or general exogenous improvements in living conditions are likely to improve health, but it is not clear that such developments only cause higher survival rates for children and *not* for adults – or the reverse. It is more reasonable to assume that both survival rates increase. Having identified, and analysed in isolation, the key dynamics of child and adult survival on economic variables, we move on to study a *composite shock* where both child survival and adult survival increase simultaneously.

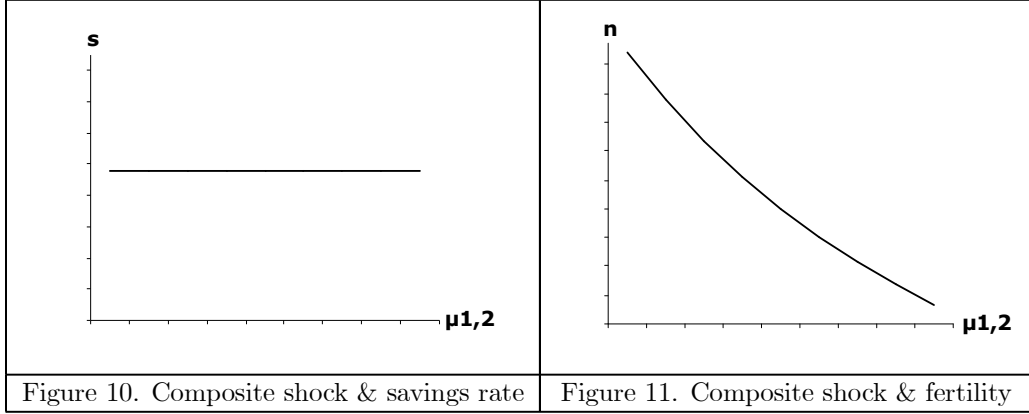
4.4 Child and adult health

The composite shock of a simultaneous and equi-proportional increase in child and adult survival will produce a combination of the effects analysed above. An increase in μ_1 (μ_2) led to a higher (lower) savings rate – thus the composite shock entails perfectly offsetting effects on the savings rate (see figure 10). This is because the ratio of the prices on first and second period consumption remain unchanged¹³.

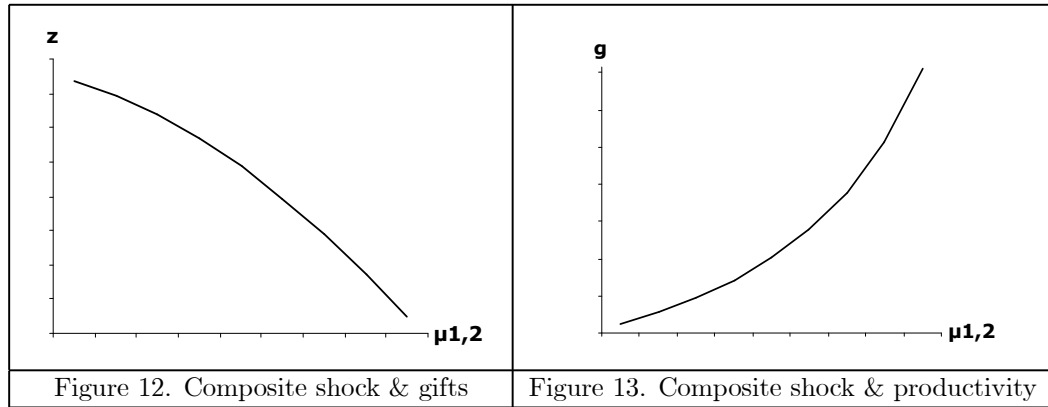
We identified three effects on savings following an increase in child survival, μ_1 . Since the effect from intertemporal prices is absent for a composite increase in survival rates, the positive effect on savings is due to the effect from a lower price on children being larger than the effect from a higher marginal utility of first period consumption. The net effect of μ_2 on savings, on the other hand, was negative and dominated by the fact that children could be used as an old age savings mechanism when the return on capital savings fell. Savings also tended to rise because an increase in μ_2 would increase the marginal utility of second period consumption.

¹³The fact that the savings rate is actually constant in our simulations for the composite increase in child and adult survival proves that our modelling of survival rates in this model is correct, because the result is perfectly in line with intuition.

The net increase in savings for a composite increase in survival rates, for that reason, will generate similar effects on fertility, productivity growth and altruistic gifts as studied in section 4.2, albeit at a lower scale because the effects on these economic variables are counteracted by the impacts of μ_2 .



The sum of effects on fertility is a clear decline, as illustrated in figure 11. This is due to increased savings, which leads to more capital, and thus income, per worker and thus more second period income and less need for children as an insurance for old age consumption. In addition, children become relatively cheaper when μ_2 increases (see the price of children: $\kappa w_t - z_{t+1} w_{t+1} \mu_2 / R_{t+1}$), so fertility falls even further (hence, altruistic gifts also fall; figure 12).

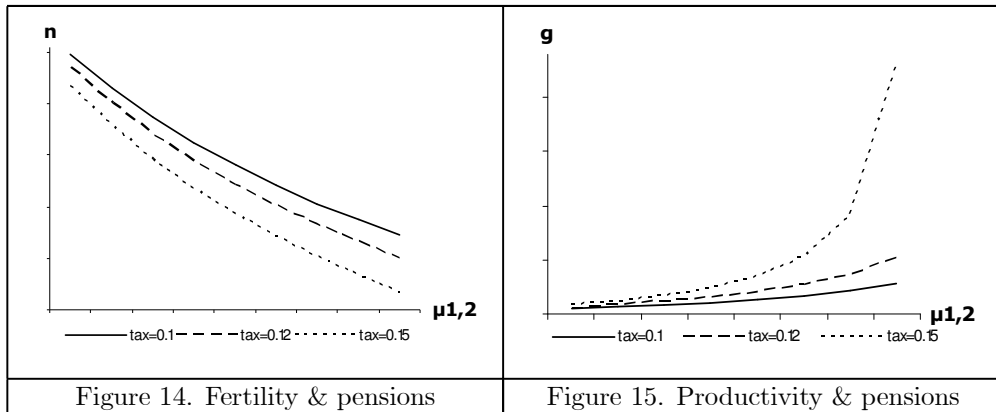


Regarding productivity growth, the increased knowledge spillovers on the wage rate will yield a higher rate of productivity growth (see figure 13). These results rest upon the assumption that μ_1 and μ_2 increase in equal proportions such that all effects on the savings rate net out. In case the increase in μ_1 is larger (smaller) than the increase in μ_2 the increases in fertility and productivity growth will also be larger (smaller).

5 Discussion

An increase in the *child* survival rate increases the number of dependents and reduces household resources. Furthermore, an increase in *adult* survival encourages savings, as we expect to live longer. This implies that improvements in child survival should have *negative* effects on economic outcomes, while improvements in adult survival should have *positive* effects. However, once we take three aspects into account: first, the negative fertility response to child survival, second, the possibility of intergenerational transfers and, third, the compounding effect on capital savings from adult survival due to substitution for less expensive children as a savings mechanism, we observe that *child* survival has a net positive effect on economic outcomes compared to the negative effect on savings from *adult* survival.

Existing literature only captures the positive effect of adult survival on capital savings, which is usually modelled in terms of increasing *life expectancy*. In our model, when fertility has declined to a certain extent, there will be no altruistic transfers as retirees obtain more and more income through capital savings. As a result, the "savings motive" for having children, facilitated by altruistic transfers, disappears and workers only have children from a "genetic motive". The model will then collapse to feature a standard OLG model with endogenous fertility – however, with survival rates still incorporated. When adult survival then increases further, the impact upon capital savings will be positive, in line with existing literature (e.g. Chakraborty, 2004; Jørgensen, 2008). The existing literature, therefore, is more targeted at *developed* countries, since it does not take into account the developing country feature of children as an old age security device.



In the model, we have incorporated the child and adult survival rates (in line with Jørgensen, 2008) into the basic setup in Wigger (2004). Wigger's key argument is that an increase in public pensions will reduce fertility and increase productivity growth. He can not study these dynamics in the context of increasing survival rates. However, based on the results reported in this paper we can show that his argument still holds: we examine the results from our composite shock of simultaneous and equi-proportional increases in child and adult survival rates (in section 4.4) for an increasing pension contribution rate, θ . We find that the fertility path (in figure 14) and productivity growth path (in figure 15) will be in the favourable directions.

The path for fertility decline will therefore shift downwards, while the path for productivity growth shifts upwards. These dynamics occur because increasing pension benefits to retirees will reduce their need for altruistic gifts. Thus, they can save resources on child rearing, and make these available for consumption and capital savings. This suggests that increasing public pensions will increase productivity growth, which is a controversial assertion.

The key dynamics to take into account is the presence of altruistic transfers and endogenous fertility. When the economy reaches the point in the demographic transition where fertility has declined so much that the only motive for having children is the genetic motive, parents realise that they can no longer save child-rearing resources by switching towards capital savings and away from having children to support them in old age. After this point, an increase in public pensions will reduce growth in line with conventional wisdom. However, while altruistic transfers are *still* operative a rise in public pensions *increases* productivity growth and *reduces* fertility – and therefore speeds up the process by which a country will go through the demographic transition.

We have argued in this paper that a shift from a fixed *contributions* PAYG system towards a fixed *benefits* system would even further reduce fertility and increase productivity growth. This will happen as parents realise that having *more* children will *not* provide them with more pension benefits, but only draw down on their resources. While this is an issue for our future research, we expect that the fertility paths would shift down even further than in figure 14, and that the paths for productivity growth would shift up even more than in figure 15.

The model incorporates perfect capital markets, which is a limitation that should be addressed in future work on this topic. We would expect that if capital markets were imperfect, the return on capital savings would fall and children be rendered more attractive as a savings mechanism¹⁴. Over the course of economic development capital markets would develop, and the relative return on capital savings would increase – depressing further the savings motive for having children and magnifying the downward pressure on fertility, as derived in this paper.

In our model we chose to abstract from education. The effects of education in an intertemporal setting are well understood: the quality/quantity trade-off informs us that an increase in child survival will lower fertility and thus increase the resources (for education) devoted to each child. If we abstract from this movement of resources, we can identify the allocation of resources to savings and intertemporal transfers going from *child to parent* (rather than from *parent to child* in the education case). In this context, an issue for our future research is to incorporate human capital formation alongside a two-sided altruism formulation of utility (modifying (6) such that $U_t = \chi u_{t-1} + u_t + \pi u_{t+1}$). This would allow us to trace the effects of better health in the demographic transition upon economic variables through a framework with altruism, two fertility motives, human capital formation and an additional feature of endogenous economic growth, respectively.

Having discussed the limitations of our analyses, and provided suggestions for future research in this area, we move to the main conclusions of the paper.

¹⁴In most developing countries an enormous problem is access to credit, savings, insurance and other capital market instruments – especially in rural areas, where microfinance is often the only (very high interest rate) option for credits.

6 Conclusion

All developed countries have gone through the demographic transition at some point in history. However, several developing countries still have not even passed through the first stage with low mortality, and for other countries the second stage of low fertility has often not even been entered. As a result, these countries are restrained from the enormous potential for economic gains that are associated with lower dependency ratios. In order to reduce poverty, it is essential for these countries to maintain high survival rates and quickly obtain low fertility, and in this paper we find that by promoting child health, countries will achieve this objective. Targeting the child survival rate for developing countries is found, in this paper, to be an appropriate policy rule. An additional key finding is that by increasing public pensions there is scope for reaching even more favourable paths for fertility and productivity growth.

Life expectancy is a measure that contains information about the age specific survival rates. A rise in child survival will increase life expectancy, as will an increase in adult survival. Our division of life expectancy into child and adult survival, respectively, is unique relative to the existing literature, where only adult survival (as a proxy for life expectancy) is modelled. We derive our results in a model with two motives for having children: the "savings motive" and the "genetic motive", and facilitate the former by incorporating, into an OLG model with endogenous fertility, the possibility for altruistic transfers from workers to their retired parents.

If either the relative opportunity cost of having children or the relative return on capital savings falls, we find a decline in capital savings and an increase in fertility, through the savings motive for having children. Such relative price changes occur when child and adult survival rates change, and we find a positive (negative) net effect on capital savings when child (adult) survival increases – which impacts upon the capital-labour ratio and thus productivity growth.

In the case where both child and adult survival rates increase simultaneously, and in equal proportions, we find no change in the savings rate, due to our modelling of survival rates as prices on consumption in the working and retirement periods, respectively. Each of these prices affects the intertemporal smoothing of resources, but our composite increase in survival rates renders the ratio of prices unchanged, and thus the savings rate remains constant. Our model consequently provides us with important insight into the savings behaviour that evolves as a country goes through the demographic transition – initiated by increasing child survival rates.

This setup leads us to conclude that an *increase* in child survival will promote *capital savings* and discourage savings through children as an old age security device. Such dynamics will ultimately lead to *lower* fertility and *higher* productivity growth. In contrast to conventional wisdom, we find that *as long as* altruistic intergenerational transfers are operative, an increase in adult survival will be detrimental to productivity growth.

The existing literature finds that increases in life expectancy (the adult survival rate) will increase capital savings and therefore economic growth, but this result is modified in the stages of economic development where the subsistence of retired

parents to some degree depends upon financing by their working-age children. As economies develop, children become less important as a "savings mechanism", and in that process adult survival gradually becomes a key to increased capital stocks – equivalent to the finding in the existing literature. In sum, the value added by our analyses relies on the dynamics of economic variables when child survival increases – and, furthermore, the modification of the former theoretical findings that increasing adult survival (life expectancy) would *unambiguously* lead to economic growth, which is not the case when there is a "savings motive" for having children.

Our simulations clearly imply that when both child and adult survival rates increase, economies will be less dependent on altruistic intergenerational transfers, which otherwise crowd out the physical capital stock and the possibility of endogenous growth, and which have the potential to retain economies in poverty traps. This directly reduces the need for children as an old age savings mechanism, and thus fertility falls. As a result, by improving health conditions for all generations, especially for children, we find that there is a potential for going through the demographic transition with lower fertility and higher productivity growth.

References

- [1] Arrow, K. J. (1962), The economic implications of learning by doing, *Review of Economic Studies*, No. 29, pp. 155-173.
- [2] Barro, R. J. and G. Becker (1989), Fertility choice in a model of economic growth, *Econometrica*, No. 57, pp. 481-502.
- [3] Barro, R. J. and J. Lee (1994), Sources of economic growth, *Carnegie Rochester Conferences Series on Public Policy*, No. 40, pp. 1-46.
- [4] Bloom, D. E. and J. Williamson (1998), Demographic transitions and economic miracles in emerging Asia, *World Bank Economic Review*, No. 12(3), pp. 419-455.
- [5] Bloom, D. E., D. Canning and J. Sevilla (2003), The demographic dividend: a new perspective on the economic consequences of population change, *Population Matters*, Monograph, MR-1274, RAND, Santa Monica.
- [6] Bloom, D. E., D. Canning and J. Sevilla (2004), The effect of health on economic growth: a production function approach, *World Development*, No. 32(1), pp. 1-13.
- [7] Bloom, D. E., D. Canning and M. Moore (2005), The effect of improvements in health and longevity on optimal retirement and savings, *PGDA working paper*, No. 2.

- [8] Bloom, D. E., D. Canning, R. Mansfield and M. Moore (2007), Demographic change, social security systems, and savings, *Journal of Monetary Economics*, No. 54(1), pp. 92-114.
- [9] Bohn, H. (2001), *Social security and demographic uncertainty: the risk-sharing properties of alternative policies*, in J. Campbell and M. Feldstein (eds.), Risk aspects of investment based social security reform, pp. 203-241, University of Chicago Press.
- [10] Bongaarts, J. (1990), The measurement of wanted fertility, *Population and Development Review*, No. 16(3), pp. 487-506.
- [11] Bongaarts, J. (1994), The impact of population policies: comment, *Population and Development Review*, No. 20(3), pp. 616-620.
- [12] Chakraborty, S. (2004), Endogenous lifetime and economic growth, *Journal of Economic Theory*, No. 116, pp. 119-137.
- [13] Chang, F. (1990), Uncertain lifetimes, retirement and economic welfare, *Economica*, New Series, Vol. 58, No. 230 (May, 1991), pp. 215-232.
- [14] Dasgupta, P. (1993), *An inquiry into well-being and destitution*. Clarendon Press.
- [15] Diamond, P. (1965), National debt in neoclassical growth models, *American Economic Review*, No. 55, pp. 1126-1150.
- [16] Ehrlich, I. and F. Lui (1991), Intergenerational trade, longevity, and economic growth, *The Journal of Political Economy*, No. 99(5), pp. 1029-1059.
- [17] Fink, G. (2007), *College education and fertility outcomes*, mimeo, Harvard School of Public Health.
- [18] Finlay, J. E. (2006), Endogenous longevity and economic growth, *Program on the Global Demography of Aging Working Paper*, No. 7, Harvard School of Public Health.
- [19] Galor, O. and D. Weil (2000), Population, technology, and growth: from Malthusian stagnation to the demographic transition and beyond, *American Economic Review*, No. 90(4), pp. 806-828.
- [20] Galor, O. and D. N. Weil (1996), The gender gap, fertility, and growth, *American Economic Review*, No. 86(3), pp. 374-387.
- [21] Jensen, S. E. H. and O. H. Jørgensen (2008), *Uncertain demographics, longevity adjustment of the retirement age and intergenerational risk-sharing*, in S. J. Alho, S. E. H. Jensen and J. Lassila (eds.), Uncertain demographics and fiscal sustainability, pp. 239-257, Cambridge University Press, (Chapter 1 in this thesis).
- [22] Jørgensen, O. H. (2008), Retirement indexation in a stochastic model with overlapping generations and endogenous labour supply, *CEBR Discussion Paper*, No. 2008-3.

- [23] Nishimura, K. and J. Zhang (1995), Sustainable plans of social security with endogenous fertility, *Oxford Economic Papers*, No. 47(1), pp. 182-194.
- [24] Pritchett, L. (1994), Desired fertility and the impact of population policies, *Population and Development Review*, No. 20(1), pp. 1-55.
- [25] Romer, P. M. (1986), Increasing returns and long-run growth, *Journal of Political Economy*, No. 94, pp. 1002-1037.
- [26] Weil, D. N. (2007), Accounting for the effect of health on economic development, *Quarterly Journal of Economics*, No. 122(3), pp. 1265-1306.
- [27] Wigger, B. U. (2002), *Public Pensions and Economic Growth*. Springer-Verlag, Heidelberg.
- [28] Zhang, J. and K. Nishimura (1993), The old-age security hypothesis revisited, *Journal of Development Economics*, No. 41, pp. 191-202.
- [29] Zhang, J. and J. Zhang (2005), The effect of life expectancy on fertility, savings, schooling and economic growth: theory and evidence, *Scandinavian Journal of Economics*, No. 107(1), pp. 45-66.