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Intergenerational Transfers of Time and Public Long-term Care with an Aging Population*

Atsue Mizushima†

August, 2008

Abstract

Although a large number of studies have been done on intergenerational transfers of goods, little is known about intergenerational transfers of time. In step with an increase in the aging of the population, the demand for time-intensive transfers in health care and other health services increases. Using an overlapping generations model which incorporates uncertain longevity, we set up a model which incorporates intergenerational transfers of time and examine the macroeconomic effect of public long-term care policy (LTC). Using the model, we show that LTC decreases the steady state level of capital, but that it enhances the welfare level when the rate of tax is sufficiently small.

Classification Numbers: E60, I12, J14, J22

Key words: time transfers, household production, overlapping generations medel

1 Introduction

Over the past few decades, a considerable number of studies have been conducted on intergenerational transfers. These studies show that altruism is important in determining dynamic resource allocation.[1] However, most of the research only considers transfers of goods; only a few papers consider transfers of time (see, for example, Cardia and Ng (2003) and Cardia and Michel

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[1]For example, fully altruistic behavior, agents' utility ultimately depends on the utility of all of their descendants and transfers resources on their descendants (e.g.Becker and Barro (1988) and Barro and Becker (1989)). From a non-altruism perspective, transfers may arise of self-interest (e.g., Cox (1987)). Alternatively, the existence of bequests may simply be an accident as in Abel (1985), and the existence of gifts may be the results of social norms or customs that obligate children to provide some form of material support to their parents during old age, as argued by Morand (1999).

(2004)). The latter are particularly important here because of the prospect of 'graying' populations in many developed economies.[2] Because physical and mental health tend to deteriorate with age, the number of people who demand time-intensive transfers in health care and other health services increases. For example, in the developed countries, the average density of practicing nurses was increased from about 2.5 (1960) to about 8.1 per thousand people (2003)(OECD (2005)). In Japan, about 94.8% of people who need health care are over 65 years of age.

The purpose of this paper is to examine the macroeconomic effect of health care in an aging economy. For this purpose, it extends a two-period overlapping generations model by introducing uncertain longevity (Pecchenino and Pollard (1997)) and household health production (Grossman (1972)). Using time, household health production determines the health status of old agents. We introduce the family as the producer of health; and assume they maximize their joint utility function. When young agents (adult-children) derive utility from the level of household health status, they contribute household health production by supplying their endowed time with respect to labor supply on market.

Previous research has examined the potential for uncertain longevity to explain the capital accumulation or economic growth. Earlier studies rely on Yaari (1965) and Blanchard (1985), who showed that an increase rate of life longevity increases capital stock. Pecchenino and Pollard (1997) and Futagami and Nakajima (2001) also have the same results. However, de la Croix and Licandro (1999), Fuster (1999), and Boucekkine, de la Croix, and Licandro (2002) conclude that there exists an inverted U-shaped relationship between life longevity and economic growth. Indeed, the results we present in this paper contradict these conclusions, and reveal that intergenerational transfers of time provide another important mechanism on capital accumulation in the model of uncertain longevity.

The increasing health care demand associated with an aging population has, nevertheless, received much attention from other scholars. Norton (2000) focuses on the supply and demand for nursing home care and on long-term care insurance. Lakdawalla and Philpson (2002) indicate that the aging of the population represents not just a new source of long-term care demand, but it may also represent a new source of long-term care supply. Unlike their long-term care model,

[2] According to Weil (1997), population aging can be seen in both a reduction in the fraction of the population that is under 20, and an increase in the fraction over 64. In developed regions, the population aged 65 or over is expected to nearly double, whereas the member of persons aged 0-24 is likely to decline. The person aged 65 or over in the more developed countries represent 15.3 % (2005) and is estimated 26.1 % (2050) of all population; and that of the person aged 0-24 represent 30.7 % (2005) and also is estimated to 25.8 % (2050) (See, United Nations (2007)).

in this paper, we focus our attention on the intra-family health care.[3]

Even in the presence in health care market and health insurance, the family is the main source of health care. For example in Japan, 74.8% of total care is provided by the family and half of this is provided by adult-children or daughters-in-law (The Ministry of Health, Labor and Welfare of Japan (2004)). In Germany, 66% of older people rely on informal care, which is delivered by families: spouses, daughters, and daughters-in-law. In Spain, nearly 70% of older people receive exclusively family care. In Italy, 47.2% of families with a 65-year-old member receive care from relatives. In the United Kingdom, the percentage of people aged 65 who receive only informal care is 53%, and the percentage that receive both informal and formal care is 34% (See, for details, Comas-Herrera, Raphael, and et al (2003, 2006)). According to NSFH (2005), 72.2% of U.S. people agree with the question: "Children should take care of elderly parents". Therefore, it seems plausible to focus on the intra-family health care when we examine the macroeconomic effect of health care in an aging economy.

Our analysis builds primarily on previous research by Cardia and Michel (2004) and Tabata (2005). Cardia and Michel (2004) study the intergenerational transfers of time by using household production; and show the impact of intergenerational transfers of time on capital accumulation and bequest behavior. In his theoretical paper, Tabata (2005) constructs a health care model which incorporates uncertainty regarding life longevity and old-age health status. He shows the consequences of goods-related health care for economic growth and welfare. We combine the aspects of these authors, and then set up a theoretical model to examine the macroeconomic effect of time-related health care. Our methodology analysis, therefore, naturally allows the alternative model to examine the macroeconomic effect of health care.

From a policy standpoint, it is important to understand the macroeconomic impact of time-related health care. If it reduces or increases the capital accumulation in an aging economy, then changes in government long-term care influence individuals' labor-care decisions and saving. Therefore, in this paper, we also construct the model of public long-term care (LTC) where the government transfers time to unhealthy old agents; then examine the macroeconomic effect of LTC.

[3]The first generation of research on families' care arrangements relies on Becker's model of the family (see, for example, Wolf and Soldo (1994) and Ettner (1996)). Most recent work has used game-theoretic bargaining models to examine family care arrangements (see, for example, Pezzin and Schone (1997, 1999)). Unlike these studies, we construct a general equilibrium overlapping generations model where young agents (adult-children) transfer their time to old agents (aged-parents); and then examine the effect of intergenerational transfers of time on capital accumulation and welfare.

The remainder of this paper is organized as follows. Section 2 sets up the model. Section 3 analyzes the equilibrium in which there is no government. Section 4 examines the role and effect of LTC on the dynamic equilibrium. Section 5 shows the effect of LTC on the steady-state level of the welfare. Section 6 concludes this paper.

2 The Model

We consider a two-period overlapping generations model which incorporates uncertainty about lifespan and illness status in old age. Time is discrete and the time horizon is infinite. The economy begins operating in period 1, and the cohort born in period t is known as generation t. Generation t is composed of a continuum of $N_t > 0$ agents who live for a maximum of two periods; that is, young and old. At each date, new generations, each consisting of a continuum of agents with a unit measure, are born. They are endowed with one unit of time when young and old. Those who are old in period 0 are the initial old.

Agents

We assume the probability that an agent lives through the period of old age is $p \in (0, 1)$. The probability that an individual dies at the beginning of the period of old age, after having had a child is $1 - p$. Thus, in this model, p shows the life longevity. If an individual is alive in his or her old age, he or she also has probability of being in unhealthy. The probability of an individual being in healthy throughout his or her old age is $\psi \in (0, 1)$; the corresponding probability of unhealthy is $1 - \psi$. Therefore, there are three different states in two periods of life: healthy, unhealthy, and death.

A fraction $p\psi$ of young agents are of type g, whose parents are healthy. Type b agents, who constitute $p(1-\psi)$ of young agents, have parents who are unhealthy. The fraction $1-p$ of young agents are of type d, whose parents die. In addition, the fraction $p\psi$ of old agents are of type g, who are healthy. Type b agents, who constitute $p(1-\psi)$ of old agents are unhealthy. The fraction $1 - p$ of old agents are of type d. We express the death-health status of each agent's parents by using the index i; each agent's own status in his or her old age is indexed by j. To simplify the analysis, we assume that the probability of death health status is not serially correlated across generation. Thus, the probabilities of the death health states θ_s $(s = i, j)$ are given as follows:

$$\theta_s = \begin{cases} p\psi & \text{if} \quad s = g, \\ p(1-\psi) & \text{if} \quad s = b, \\ (1-p) & \text{if} \quad s = d. \end{cases} \tag{1}$$

In the model, we introduce the family as the producer of health. In economic theories about family, it is assumed that the family maximizes a joint 'welfare function' (Becker (1991)).[4] By using this assumption, the household-produced health function is given by the sum of individual time: that is, adult-children's and parents' time:[5]

$$h_{j,t} \quad = \quad d_j q_{i,t}^{\,t} + \gamma_j, \quad j = g, b, \tag{2}$$

where $d_j \geq 1$ is a productivity parameter such that $d > \max\{1, \frac{\gamma}{\beta}\}$ if $j = g$ and $d = 1$ if $j = b$. The restriction of d_j shows that when old agents are healthy, their productivity is higher than unhealthy old agents, and it also ensures the interior solution of the care provision. In addition, $q_{i,t}^{\,t}$ represents care provision from type i children to parents, and γ_j represents the productivity of old agents. Each old agent supplies one unit of time to produce household health production, although health productivity in old age is less than that of young age: $\gamma < 1$ if $j = g$; and $\gamma = 0$ if $j = b$, which is given exogenously. The productivity of old agents shows when altruism is large, children supply a great deal of time to household health production, and that this altruism enhances the productivity of old agents.

We assume that each agent of generation $t \geq 1$, whose parents' death health status is i has the following utility function over consumption and household health status:

$$\begin{aligned} \max_{h_{i,t}, c_{i,t+1}^{\,t}} U_i \quad &\equiv \quad Eu(h_{i,t}\,, c_{i,t+1}^{\,t}\,, h_{j,t+1}\,; p, \psi) \\ &= \quad \beta \ln h_{i,t} + p(\ln c_{i,t+1}^{\,t} + \psi \ln h_{g,t+1} + (1-\psi) \ln h_{b,t+1}) \quad i, j = g, b, d, \end{aligned} \tag{3}$$

where $c_{i,t+1}^{\,t}$ is the consumption of market goods during old age, and $\beta \in (0, 1)$ measures the degree of altruism towards parents. p and ψ are realized at the beginning of each period.

Since each agent is endowed with one unit of time, he or she allocates his or her time to household health production $q_{i,t}^{\,t}$ and to market place producing market goods $l_{i,t}^{\,t}$. Each young agent earns wage income $w_t l_{i,t}^{\,t}$ by working at the market place, and saves all the wage income for his or her old age. When old, he of she receives the proceeds of his or her savings and allocates his or her endowed time to household health production. Following Yaari (1965) and Blanchard (1985), we assume the existence of actuarially fair insurance companies. These companies collect funds and invest them in firms. Returns on investments are repaid to the insured household members who are still living. In other words, the contract offered by the insurance company redistributes income from the dead to the living.

[4] The well-known work on the allocation of time in the family of Gronau (1973) also use this assumption.
[5] See Grossman (1972) and Jacobson (2000) for health production function.

Suppose that the insurance company collects e_t from young agents (and thereby $E_t \equiv e_t N_t$ in the aggregate) in period t. (Note that old agents have no incentive to buy the annuity because they are not alive in the subsequent period.) The company invests the funds for the firms and acquires total proceeds of $R_{t+1}E_t$ in period $t+1$. Given that only pN_t old agents who survive in period $t+1$ can receive $R_{t+1}e_t/p$ from the insurance company (because of perfect competition between companies). Thus, the rate of return on the annuities is R_{t+1}/p for the living and 0 for those who die at the end of period t. On the other hand, if young agents in period t invest e_t directly in their firms, they receive $R_{t+1}e_t$ whether they are alive or dead. (For agents who do not live to the next period, their children inherit the funds.) Thus, the rate of return on self-investment is R_{t+1}. Because we assume that agents have no bequest motive, they accept the insurance contract, which yields a higher interest rate than does self-investment. Thus, the budget constraints of generation t, and their parents' death-health status $i = g, b, d$, are $c_{i,t+1}^{\ t} = R_{t+1} w_t l_{i,t}^{\ t}/p$. By combining the time constraints $l_{i,t}^{\ t} + q_{i,t}^{\ t} = 1$, we have the following lifetime budget constraint:

$$c_{i,t+1}^{\ t} = \frac{R_{t+1}}{p} w_t (1 - q_{i,t}^{\ t}), \quad i = g, b, d. \tag{4}$$

In each period, the time spent in the household on household health production or that spent in the market place producing market goods must be nonnegative and must not exceed unity, as follows:

$$0 \leq q_{i,t}^{\ t} \leq 1, \quad \text{and} \quad 0 \leq l_{i,t}^{\ t} \leq 1, \quad i = g, b, d. \tag{5}$$

Taking R_{t+1}, w_t, p, and ψ as given, each young agent maximizes the expected utility of (3) subject to (2), (4), and (5). The first order condition yields the care provision as follows:[6]

$$q_{i,t}^{\ t} = \begin{cases} \dfrac{\beta d - \gamma p}{d(p+\beta)} & \text{if } i = g, \\ \dfrac{\beta}{p+\beta} & \text{if } i = b, \\ 0 & \text{if } i = d. \end{cases} \tag{6}$$

Because an increase in life longevity p increases the opportunity cost of care provision, it decreases the care provision of young agents. We derive aggregate care provision by summing up (6) by using (1):

$$Q_t \equiv q_t N_t = \sum_{i=g,b,d} \theta_i q_{i,t}^{\ t} N_t = \Big(\frac{p}{p+\beta} \Big(\beta - \frac{p\psi\gamma}{d} \Big) \Big) N_t.$$

[6] See Appendix 1 for derivation.

From the resource constraints, we obtain the aggregate labor supply as follows:

$$L_t \equiv l_t N_t = \sum_{i=g,b,d} \theta_i l_{i,t}^{\ t} N_t = \Big(1 - \frac{p}{p+\beta}\Big(\beta - \frac{p\psi\gamma}{d}\Big)\Big) N_t. \tag{7}$$

Young agents save all their wage income, aggregate savings are $S_t \equiv s_t N_t = w_t l_t N_t$. Dividing both sides by N_t, we have the following savings functions.

$$s_t = w_t l_t = w_t \Big(1 - \frac{p}{p+\beta}\Big(\beta - \frac{p\psi\gamma}{d}\Big)\Big).$$

Firms

Firms are perfectly competitive profit maximizers that produce output according to a Cobb–Douglas production function of the form, $Y_t = AK_t^{\alpha}(l_t N_t)^{1-\alpha}$, where Y_t is aggregate output, $A > 0$ is a productivity parameter, and K_t is the aggregate capital stock. The production function can be rewritten in intensive form as $y_t = A(k_t)^{\alpha}(l_t)^{1-\alpha}$, where $k_t \equiv K_t/N_t$ is the per capita level of capital. We assume that capital depreciates fully in the process of production. Given that firms are price takers, they take the wage w_t and the real rental price of capital R_t as given; and then hire labor and capital so that their marginal products equal their factor prices:

$$w_t = (1-\alpha)A\tilde{k}_t^{\alpha}, \quad R_t = \alpha A \tilde{k}_t^{\alpha-1}, \tag{8}$$

where $\tilde{k}_t \equiv k_t/l_t$ is the capital–labor ratio.

3 Equilibrium

As a benchmark case, we first examine the economy in which there is no government. In Section 4, we analyze an economy in which there is public policy. We first derive the equilibrium in the goods market. The equilibrium condition of the capital market is given by $K_{t+1} = s_t N_t = w_t l_t N_t$, which implies that the savings of young agents in generation t forms the aggregate capital stock in period $t+1$. Dividing both sides by N_t and using (8) yields the following equilibrium condition of the capital market.

$$k_{t+1} = (1-\alpha)Ak_t^{\alpha} l_t^{1-\alpha} \tag{9}$$

In period 1, there are the young agents of generation 1 and the initial old agents of generation 0. The initial old agents of generation 0 are endowed with k_1 units of capital. Each old agent rents his or her capital to the insurance firms and earns an income of $(R_1/p)k_1$, which is then consumed. The measure of initial old individuals is $pN_0 > 0$. The utility obtained by each individual in generation 0 is $c_1^0 + \psi \ln h_{g,1}^{\ 0} + (1-\psi)\ln h_{b,1}^{\ 0}$.

Definition 1 *The economic equilibrium is a sequence of allocations and prices,* $\{\{c_{i,t}^{\ t}, q_{i,t}^{\ t}, l_{i,t}^{\ t}, s_{i,t}^{\ t}\}_{i=g,b,d}, k_t, y_t, w_t, r_t\}_{t=1}^{\infty}$*, given the initial condition* $k_1 = K_1/N_1 > 0$*, such that all individual's utility levels are maximized, firms' profits are maximized, and all markets are cleared.*

Using (7) and (9), we have the following low of motion of k_t:

$$k_{t+1} = (1-\alpha)Ak_t^{\alpha}\Big(1 - \frac{p}{p+\beta}\Big(\beta - \frac{p\psi\gamma}{d}\Big)\Big)^{1-\alpha}. \tag{10}$$

Since the law of motion (10) is concave function with respect to k_t, letting $k_{t+1} = k_t = k^*$ in (10), we have the following steady-state level of capital stock:

$$k^* = \Big((1-\alpha)A\Big)^{\frac{1}{1-\alpha}}\Big(1 - \frac{p}{p+\beta}\Big(\beta - \frac{p\psi\gamma}{d}\Big)\Big). \tag{11}$$

Proposition 1 *Suppose that* $d > \max\{\max\{\frac{\gamma}{\beta}, 1\}, \frac{\psi\gamma(1+2\beta)}{\beta^2}\}$*, an increase in life longevity decreases steady state level of capital stock.*

Proof. See, Appendix 2. ■

The intuition of Proposition 1 is as follows. In our model, an increase in life longevity has two effects on the capital accumulation. One is the 'demographic effect', which operates through aggregate labor supply for household health production. Because aggregate care provision for household health production is formalized as $Q_t \equiv q_t N_t = \sum_{i=g,b,d} \theta_i q_{i,t}^{\ t} N_t$, care provision increases with life longevity p. Therefore, an increase in life longevity lowers aggregate labor supply and savings. Thus, the demographic effect has a negative impact on the capital accumulation. The other effect is the 'time preference effect'. In our mode, the interest rate is an increasing function of life longevity p; thus, an increase in life longevity can be interpreted as the rate of time preference, as incorporated in models such as those of Yaari (1965), Blanchard (1985), Pecchenino and Pollard (1997), and Futagami and Nakajima (2001). Therefore, an increase in life longevity lowers each agent's rate of time preference and increases savings. Thus, the time preference effect has a positive impact on the capital accumulation. An increase in the productivity d increases the marginal utility of household health production and results in a higher care supply. Therefore, the demographic effect dominates the time preference effects to obtain the result.

4 Public Long-term Care Policy

In the preceding sections, we described the economy where there is no government. In this section, we introduce a government that provides public long-term care policy (LTC) to unhealthy old agents.

We assume that LTC is implemented as follows. First, the government levies a payroll tax τ on young agents (generation t). Second, the government employs each young agent (generation t) $z_{i,t}^{t}$ and transfers time $\hat{z}_t$ to unhealthy old agents (generation $t-1$). When old agents supply their one unit of time to the household health production, type g agents have a productivity level of $\gamma > 1$, whereas type b agents do not. Thus, LTC complements the productivity of type b old agents by providing $\hat{z}_t \leq \gamma$ units of public care provision to those agents.

Because each young agent supplies $z_{i,t}^{t}$ time to the public care market in an economy with LTC, aggregate public care provision Z_t is determined as $Z_t \equiv z_t N_t = \sum_{i=g,b,d} \theta_i z_{i,t}^{t} N_t$, and is divided among unhealthy old agents. Thus, unhealthy old agents can receive an amount of public care provision $\hat{z}_t = z_t/p(1-\psi)$ through LTC.

The government collects payroll taxes from young agents who work in the market place and in the public care market, and repays these revenues to young agents who work in the public care market. For analytical simplicity, we assume that perfect substitution prevails between the market place and the public care market, that is, the wage rates are equalized in both markets. Thus we have the following budget constraint:

$$\tau(l_t + z_t)w_t = z_t w_t \tag{12}$$

The left-hand side represents aggregate tax income collected by the government. The right-hand side represents aggregate expenditure on the public care provision.

Given that the government transfers time to old agents (generation $t-1$), the type b old agents (generation $t-1$) can receive public care. Thus the household health production function of type b agents is rewritten as follows:

$$h_{b,t} = q_{b,t}^{t} + \hat{z}_t. \tag{13}$$

In addition, each young agent allocates his or her time to market place, family care, and

public care, his or her constraints are written as follows:

$$l_{i,t}^{\ t}+q_{i,t}^{\ t}+z_{i,t}^{\ t}=1, \qquad i=g,b,d, \tag{14}$$

$$c_{i,t+1}^{\ t}=\frac{R_{t+1}}{p}(1-\tau)w_t(l_{i,t}^{\ t}+z_{i,t}^{\ t}), \qquad i=g,b,d, \tag{15}$$

$$0\leq q_{i,t}^{\ t}\leq 1,\quad 0\leq l_{i,t}^{\ t}\leq 1,\quad 0\leq z_{i,t}^{\ t}\leq 1, \qquad i=g,b,d. \tag{16}$$

From (14) and (15), we obtain the lifetime budget constraint as follows:

$$c_{i,t+1}^{\ t}=\frac{R_{t+1}}{p}(1-\tau)w_t(1-q_{i,t}^{\ t}), \qquad i=g,b,d. \tag{17}$$

Taking $R_{t+1}, w_t, \tau, \hat{z}_t, p$, and ψ as given, each young agent whose parents' death health status is $i=g$ (or $i=b$) maximizes (3) subject to (2) (or (13)), (16), and (17). Solving this problem by using a similar method to that used in Section 2, we can describe the optimal allocation as follows:

$$q_{i,t}^{\ t}=\begin{cases}\frac{1}{d}\Big(\frac{\beta d-\gamma p}{p+\beta}\Big) & \text{if } \ i=g,\\ \frac{\beta-p\hat{z}}{p+\beta} & \text{if } \ i=b,\\ 0 & \text{if } \ i=d.\end{cases} \tag{18}$$

LTC compensates the care provision of type b agents whose parents are unhealthy, thus adult-children decrease their care provision to household health production. Solving the program as the same way with Section 2, we have the aggregate care supply as follows:

$$Q_t\equiv q_tN_t=\sum_{i=g,b,d}\theta_iq_{i,t}^{\ t}N_t=\frac{p}{p+\beta}\Big(\beta-\frac{p\psi\gamma}{d}-p(1-\psi)\hat{z}\Big)N_t. \tag{19}$$

From (14) and (18), we obtain the following aggregate labor supply.[7]

$$L_t=l_tN_t=\Big(\frac{(1-\tau)[p(1+\frac{p\psi\gamma}{d}-\beta)+\beta]}{p(1-\tau)+\beta}\Big)N_t. \tag{20}$$

4.1 Equilibrium with LTC

In this subsection, we derive the equilibrium of the economy with LTC. To find the equilibrium, we examine the equilibrium condition of goods market. The savings of young agents form the aggregate capital stock in period $t+1$, thus it is derived as $K_{t+1}=s_tN_t=(1-\tau)w_t(l_t+z_t)N_t$. Dividing both sides by N_t and substituting $z_t=\tau l_t/(1-\tau)$ (see, (12)) into this equilibrium condition, we have the following equilibrium condition:

$$k_{t+1}=(1-\alpha)Ak_t^{\alpha}l_t^{1-\alpha}. \tag{21}$$

[7] Aggregate labor supply is derived as $L_t\equiv l_tN_t=(p\psi(1-q_{g,t}^{\ t}-z_{g,t}^{\ t})+p(1-\psi)(1-q_{b,t}^{\ t}-z_{b,t}^{\ t})+(1-p)(1-z_{d,t}^{\ t}))N_t$. Noting that $p(1-\psi)\hat{z}_t=z_t$ and $z_tN_t=\frac{\tau}{1-\tau}l_t$ (see, (12)), we have the result.

Using (8), (20), and (21), we have the following low of motion of k_t:

$$k_{t+1} = (1-\alpha)Ak_t^{\alpha}\Big(\frac{(1-\tau)[p(1+\frac{p\psi\gamma}{d}-\beta)+\beta]}{p(1-\tau)+\beta}\Big)^{1-\alpha}. \tag{22}$$

Since the law of motion (22) is concave function with respect to k_t, letting $k_{t+1} = k_t = k^*$ in (22), we have the following steady-state level of capital stock.

$$k^* = \big((1-\alpha)A\big)^{\frac{1}{1-\alpha}}\Big(\frac{(1-\tau)[p(1+\frac{p\psi\gamma}{d}-\beta)+\beta]}{p(1-\tau)+\beta}\Big). \tag{23}$$

Proposition 2 *LTC lower the steady state level of capital stock.*

LTC has two effects on the capital accumulation. One is a "tax burden effect". Under the regime of LTC, the government levies a payroll tax, which increases the opportunity cost of labor supply and reduces labor supply and saving. Thus, it has a negative impact on the capital accumulation. The other effect is a "public care effect". LTC reduces the opportunity cost of care provision; it decreases the care provision of type b agents and increases labor supply and saving. Although LTC decreases the care provision of type b agents, only the public sector compensates the care provision; thus the second effect has no impact on saving. Therefore, LTC decreases the steady state level of capital.

Proposition 3

(1) Suppose that $\tau > \beta$, an increase in life expectancy increases the steady-state level of capital.
(2) Suppose that $\tau < \beta$ and that $d > \frac{\psi\gamma(1-\tau+2\beta)}{\beta(\beta-\tau)}$, an increase in life expectancy decreases the steady-state level of capital.

Proof. See, Appendix 3. ■

Since per capita public care provision to unhealthy old agents increases with the tax rate, it increases time preference effect. Thus agents increase saving and steady-state level of capital. In addition, an increase in altruism increases the care provision to household health production, increases demographic effect and decreases the steady-state level of capital.

5 Welfare Analysis

In this section, we examine the welfare impact of LTC. To do so, we compare the level of welfare in the economy without LTC (in which $\tau = 0$) and with LTC (in which $\tau > 0$). Because it is complicated to analyze the allocation, we limit our attention to the steady-state in the rest of

this section. We define the steady-state level of welfare as the sum of agents' lifetime utilities, which are given by (3). This sum is formulated as follows:

$$\begin{aligned} W &= \sum_{i=g,b,d} \theta_i u_i \\ &= p^2\psi \ln c_g + p^2(1-\psi)\ln c_b + p(1-p)\ln c_d + p(1+\beta)(\psi \ln h_g + (1-\psi)\ln h_b). \quad (24) \end{aligned}$$

where h_g, h_b, and $c_i (i = g, b, d)$ respectively represent the steady-state levels of health status and consumption of each agent.

To facilitate comparison, we denote the steady-state levels of the welfare at the economy without LTC as index n and the economy with LTC as index s. As $\ln c_g^n = \ln\{\frac{Rw}{p}\frac{p}{p+\beta}\frac{d+\gamma}{d}\}, \ln c_b^n = \ln\{\frac{Rw}{p}\frac{p}{p+\beta}\}, \ln c_d^n = \ln\{\frac{Rw}{p}\}, \ln h_g = \ln\{\frac{\beta(d+\gamma)}{p+\beta}\}$, and $\ln h_b = \ln\{\frac{\beta}{p+\beta}\}$, substituting the steady-state values into (24), we have the welfare level without LTC, W^n as follows:

$$\begin{aligned} W^n &= p\ln\left\{\frac{Rw}{p}\right\} + p^2\psi\ln\left\{\frac{p}{p+\beta}\frac{d+\gamma}{d}\right\} + p^2(1-\psi)\ln\left\{\frac{p}{p+\beta}\right\} \\ &+ p\psi(1+\beta)\ln\left\{\frac{\beta(d+\gamma)}{p+\beta}\right\} + p(1-\psi)(1+\beta)\ln\left\{\frac{\beta}{p+\beta}\right\}. \quad (25) \end{aligned}$$

Given that $\ln c_g^s = \ln\{\frac{Rw(1-\tau)}{p}\frac{p}{p+\beta}\frac{d+\gamma}{d}\}, \ln c_b^s = \ln\{\frac{Rw(1-\tau)}{p}\frac{p(1+\hat{z})}{p+\beta}\}, \ln c_d^s = \ln\{\frac{Rw(1-\tau)}{p}\}, \ln h_g^s = \ln\{\frac{\beta(d+\gamma)}{p+\beta}\}$, and $\ln h_b^s = \ln\{\frac{\beta(1+\hat{z})}{p+\beta}\}$, W^n is measured as follows:

$$\begin{aligned} W^s &= p\ln\{\frac{Rw}{p}(1-\tau)\} + p^2\psi\ln\{\frac{p}{p+\beta}\frac{d+\gamma}{d}\} + p^2(1-\psi)\ln\{\frac{p}{p+\beta}(1+\hat{z})\} \\ &+ p\psi(1+\beta)\ln\left\{\frac{\beta(d+\gamma)}{p+\beta}\right\} + p(1-\psi)(1+\beta)\ln\left\{\frac{\beta}{p+\beta}(1+\hat{z})\right\}. \end{aligned}$$

To determine the benefit (or harm) of LTC, we subtract W^s from W^n, as follows:

$$W^n - W^s = p\Big(-\ln\{1-\tau\} - (1-\psi)(1+\beta+p)\ln\{1+\hat{z}\}\Big). \quad (26)$$

It is complicate to investigate the effect of life longevity on welfare level analytically, we provide numerical examples. Since $W^c - W^s$ is a linear function of p, and $W^c - W^s$ takes 0 when $p = 0$, thus we examine the inside of braces in (26) to determine the value of $W^c - W^s$. Calculating (26), we have the following proposition.

Proposition 4 *If* $\frac{\ln(1-\tau)}{(1-\psi)(2+\beta)} > \ln(1 + \frac{\tau(1+\frac{\psi\gamma}{d})}{(1-\psi)(1+\beta-\psi)})$, *then there exists a unique* $p^* \in (0,1)$ *such that* $W^c > W^s \ \forall \in (0, p^*]$ *and* $W^c < W^s \ \forall \in [p^*, 1)$.

Proof. See Appendix 4.

$W^n - W^s$ can be rewritten as $p(1-\psi)(1+\beta+p)\Big(-\frac{\ln\{1-\tau\}}{(1-\psi)(1+\beta+p)} - \ln\{1+\hat{z}\}\Big)$. Define $\Gamma(p;\tau) \equiv -\frac{\ln\{1-\tau\}}{(1-\psi)(1+\beta+p)} - \ln\{1+\hat{z}\}$, $\partial\Gamma(p;\tau)/\partial p = \frac{\ln(1-\tau)}{(1-\psi)(1+p+\beta)^2}$

Define $\Gamma(p;\tau) \equiv -\ln\{1-\tau\} - (1-\psi)(1+\beta+p)\ln\{1+\hat{z}\}$, $\partial\Gamma(p;\tau)/\partial p =$ ■

Lemma 1 *For a given level of life expectancy, there exists a unique* $\tau^* \in (0,1)$ *such that* $W^n > W^s$ $\forall \tau \in (0, \tau^*]$ *and* $W^n < W^s$ $\forall \tau \in [\tau^*, 1)$.

Proof. See Appendix 5.

Since $-\frac{\partial \ln(1-\tau)}{\partial \tau} = \frac{1}{1-\tau} > 0, -\frac{\partial^2 \ln(1-\tau)}{\partial \tau^2} = \frac{1}{(1-\tau)^2} > 0, \lim_{\tau \to 0} - \ln(1-\tau) = 0, \lim_{\tau \to 1} - \ln(1-\tau) = \infty$, $(1-\psi)(1+p+\beta)\frac{\partial \ln(1+\hat{z})}{\partial \tau} = (1-\psi)(1+p+\beta)\frac{p[p(1+\frac{p\psi\gamma}{d}-\beta)+\beta]}{\beta[p\beta(1-\psi)+p(1+\frac{p\psi\gamma}{d}-\beta)+\beta]} > 0, \lim_{\tau \to 0}(1-\psi)(1+p+\beta)\ln(1+\hat{z}) = 0$, and $\lim_{\tau \to 1}(1-\psi)(1+p+\beta)\ln(1+\hat{z}) = (1-\psi)(1+p+\beta)\ln\{1+\frac{p(1+\frac{p\psi\gamma}{d}-\beta)+\beta}{p\beta(1-\psi)}\} > 0$. Therefore there exists a unique $\tau^* \in (0,1)$ such that $(1-\psi)(1+\beta+p)\ln(1+\hat{z}) > -\ln(1-\tau) \forall \tau (0, \tau^*]$ and $(1-\psi)(1+\beta+p)\ln(1+\hat{z}) < -\ln(1-\tau) \forall \tau [\tau^*, 1)$. It follows $W^s > W^n$ $\forall \tau \in (0, \tau^*]$ and $W^s < W^n$ $\forall \tau \in [\tau^*, 1)$. ■

The welfare gain (or loss) that arises in an economy with LTC (in which $\tau > 0$) can be interpreted as comprising a 'health status effect', a 'capital stock effect', and a 'subsidy effect'. The health status effect is represented by the first term on the right-hand side of (26). The steady-state level of the health status improves when LTC is introduced, thus, a negative value in (26) would be obtained. LTC also has a capital stock effect on the welfare. Because LTC implies a lower steady-state level of capital, it leads to lower steady-state levels of income and welfare. This effect is represented by the second term on the right-hand side of (26). In addition to these two effects, we have the subsidy effect on the welfare. Because old agents can receive public care provision without paying tax, this effect enhances the steady-state level of the welfare of old agents.

When the tax rate is low, the negative health status and subsidy effects dominate the positive capital stock effect. However, when the tax rate is sufficiently high, labor supply falls in the economy with LTC. Consequently, LTC has a larger positive effect on the capital stock. Thus, the positive capital stock effect outweighs the negative health status and subsidy effects.

6 Conclusion

In this paper, our aim was to analyze the macroeconomic impact of intergenerational transfers of time from adult-children to their aged-parents in an aging population. To examine these issues, we extend a two-period overlapping generations model by introducing uncertain longevity and household health production. We also assumed that (i) old agents use a household health production with time as only input to improve their own health status; and (ii) young agents can contribute to this production by transfers their time.

Using this framework, in the first part of this paper, we described an economy in which there is no government. We showed that life longevity has a negative impact on the steady state level of capital. To examine how the changes in government long-term care influence individuals' saving decisions and welfare, in the second part of this paper, we introduced a government which provides public long-term care policy (LTC). We showed that LTC lowers the steady state level of capital, however, when the tax rate is small, LTC enhances the steady state level of welfare.

7 Appendix

Appendix 1

type g agent: The first order condition with respect to s_{t+1} is given by

$$\frac{\partial u_{t+1}}{\partial q^t_{g,t}} = \frac{\beta d}{d q^t_{t,t} + \gamma} - \frac{p}{1 - q^t_{g,t}} \lesseqqgtr 0 \qquad \text{with equality if } \ 0 < q^t_{g,t} < 1.$$

Since $d > \frac{\gamma}{\beta}$, we have $q^t_{g,t} = \frac{\beta d - \gamma p}{d(p+\beta)}$.

type b agent: The first order condition with respect to s_{t+1} is given by

$$\frac{\partial u_{t+1}}{\partial q^t_{b,t}} = \frac{\beta}{q^t_{b,t}} - \frac{p}{1 - q^t_{g,t}} \lesseqqgtr 0 \qquad \text{with equality if } \ 0 < q^t_{b,t} < 1.$$

Solving this problem, we have $q^t_{b,t} = \frac{\beta}{p+\beta}$.

type d agent: If the parents of young agents die, agents derive any utility from household health production, thus we obtain $q^t_{d,t}$.

Appendix 2

Since $\frac{\partial k^*}{\partial p} = \frac{((1-\alpha)A)^{\frac{1}{1-\alpha}}}{(p+\beta)^2}\left(\frac{\psi\gamma}{d}p^2 + \frac{2\psi\gamma\beta}{d}p - \beta^2\right)$, the inside of parenthesis in right-hand side determines the sign. Let us define $F(p) \equiv \frac{\psi\gamma}{d}p^2 + \frac{2\psi\gamma\beta}{d}p - \beta^2$, $F(0) = -\beta^2 < 0$ and $F(1) = \frac{\psi\gamma}{d} + \frac{2\psi\gamma\beta}{d} - \beta^2 < 0$ when $d > \frac{\psi\gamma(1+2\beta}{\beta^2}$. Therefore, when $d > \frac{\psi\gamma(1+2\beta)}{\beta^2}$, $F(p) < 0$ for $p \in (0,1)$.

Appendix 3

Since $\frac{\partial k^*}{\partial p} = \frac{((1-\alpha)A)^{\frac{1}{1-\alpha}}(1-\tau)}{(p(1-\tau)+\beta)^2}\left(\frac{\psi\gamma}{d}(1-\tau)p^2 + \frac{2\psi\gamma\beta}{d}p + \beta(\tau-\beta)\right)$, the inside of parenthesis in right-hand side decides the sign. Let us define $G(p) \equiv \frac{\psi\gamma}{d}(1-\tau)p^2 + \frac{2\psi\gamma\beta}{d}p + \beta(\tau-\beta)$, $G(0) = \beta(\tau-\beta)$ and $G(1) = \frac{\psi\gamma}{d}(1-\tau) + \frac{2\psi\gamma\beta}{d} + \beta(\tau-\beta)$. When $\tau > \beta$, $G(p)$ has two negative roots, thus $G(p) > 0$ for $p \in (0,1)$. When $\tau < \beta$ and $d > \frac{\psi\gamma(1-\tau+2\beta}{\beta(\beta-\tau)}$, $G(0) < 0$ and $G(1) < 0$. Thus $G(p) < 0$ for all $p \in (0,1)$.

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