図6 改革の年齢階層別所得格差への影響（平均対数偏差）

1998年・等価所得・再分配所得ベース

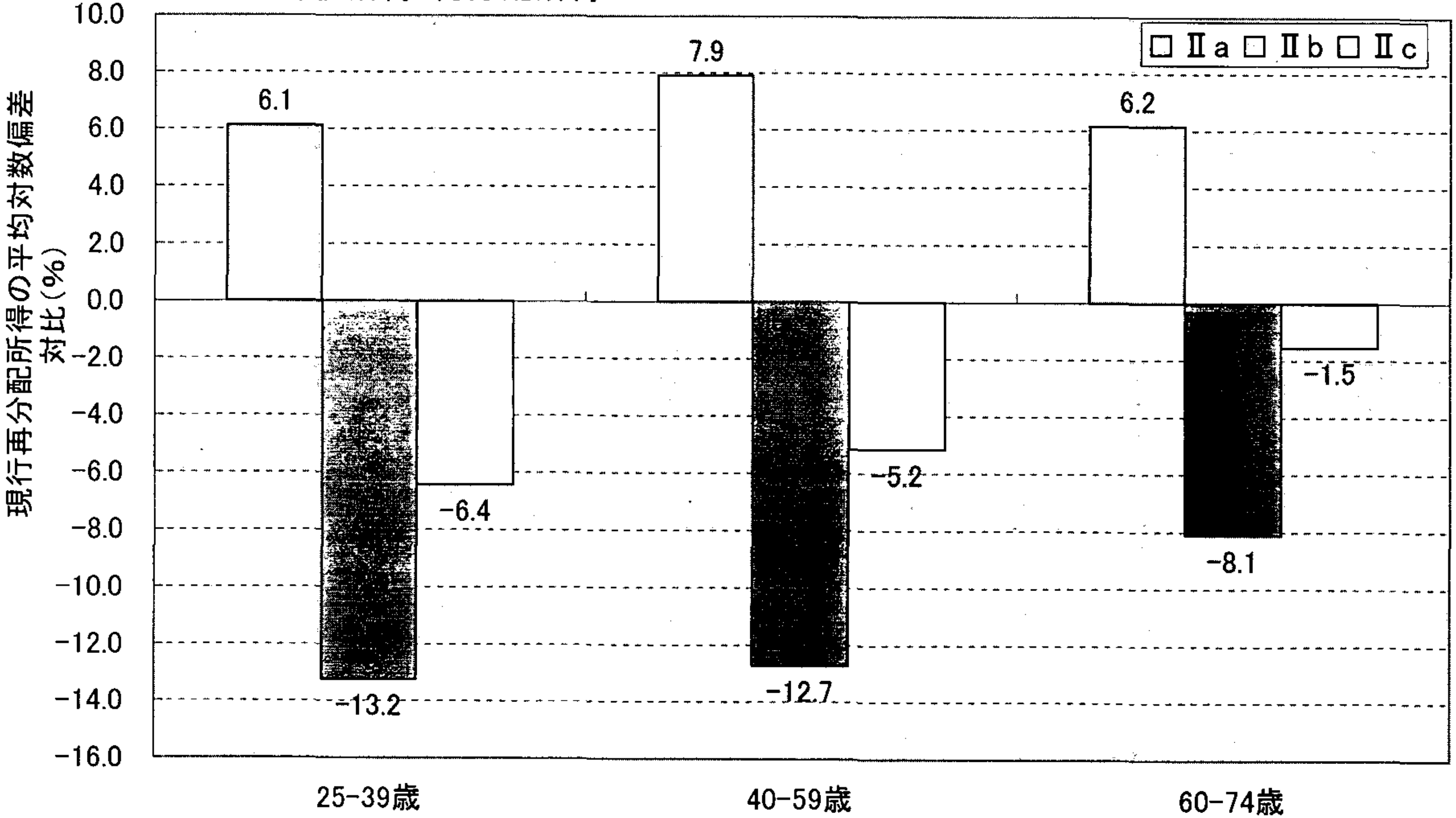

表6　各社会保険料を当初所得に比例させた場合の効果(等価所得ベース, 1998年)

ケース	現行	全体	健保	国保	厚年・共済	国年	その他
改革の結果							
平均対数偏差	0.232	0.203	0.224	0.222	0.220	0.224	0.231
対数分散	0.563	0.454	0.530	0.525	0.518	0.532	0.559
アトキンソン指数(ε =1)	20.7	18.4	20.1	19.9	19.8	20.1	20.6
同(ε =0.5)	10.3	9.4	10.1	10.0	9.9	10.1	10.3
現行からの乖離							
平均対数偏差	変化率(%)	−12.3	−3.2	−4.3	−4.9	−3.2	−0.4
対数分散	変化率(%)	−19.4	−5.8	−6.8	−7.9	−5.5	−0.7
アトキンソン指数(ε =1)	変化幅(%ポイント)	−2.3	−0.6	−0.8	−0.9	−0.6	−0.1
同(ε =0.5)	変化幅(%ポイント)	−0.9	−0.2	−0.3	−0.4	−0.2	0.0

(注)健保＝被用者保険(健保等), 国保＝国民健康保険, 厚年・共済＝被用者保険(厚生年金保険など),
国年＝国民年金・農業者年金, その他＝その他(雇用保険等.

Social Security and

Intragenerational Redistribution of Lifetime Income in Japan*

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Abstract

This paper investigates how social security redistributes lifetime income within the same generation in Japan, based on data from the Survey on the Redistribution of Income. The progressivity of Japan's public pension program appears to be much more limited on a lifetime basis than on an annual basis. Given an aging population, replacing the current pay-as-you-go system with a simple one that consists of a flat benefit and a wage-proportional premium, and has no maximum contribution, can be desirable in terms of both efficiency and intragenerational equity. The redistributive effects of income tax and consumption tax to finance the benefit are also examined.

JL classification: H55, H23

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1. Introduction

The social security system redistributes income from the young to the old, because it generally has a pay-as-you-go (PAYGO) structure. This redistributive effect, especially of public pension programs, is sometimes assessed from two viewpoints. First, with a rapidly aging population a PAYGO system is likely to entail substantial income transfers across generations and reduce the net lifetime incomes of young and future generations. There have been many attempts to empirically address the issues of intergenerational redistribution and inequality by selecting a representative individual of each generation. Hatta, Oguchi, and Sakamoto (1998) and Takayama and Kitamura (1999) are recent examples of studies from this standpoint in Japan. However, the models of heterogeneous individuals can yield ambiguous results; for instance, the possibility cannot be ruled out that individuals with lower incomes can earn net social security transfers from the government due to the progressive benefit and premium/tax formula, even if the average net income of the generation to which they belong falls under a PAYGO system.

Second, social security is often expected to reduce income inequality on an annual basis, because the old who receive benefits are poorer on average than the young who pay premiums and taxes. Indeed, the Ministry of Health, Labor, and Welfare (2002) emphasized that social security as a whole succeeds in holding down the Gini index, which has been on a clear upward trend in recent years in Japan. However, this type of assessment tends to be misleading, because each individual experiences being young and old in his or her life. Indeed, comparing the data from the 1981 and 1993 Surveys on the Redistribution of Income, Ohtake and Saito (1999) found that while the effects of redistribution policies were brought about mainly by a reduction of differentials within age groups in 1981, the narrowing of income gaps between age groups made a greater contribution in 1993. Based on these results, they pointed out the problem of simply linking a reduction of income differentials with an evaluation of redistribution policies. In addition, Teruyama and Ito (1994) decomposed the cross-sectional inequality of income and wealth into intra-age inequality ("true inequality") and inter-age inequality ("apparent inequality"), using an overlapping generations model.

One of the key issues uncovered by these two types of discussion is intragenerational redistribution on a lifetime basis; that is, how social security as a life-cycle program *redistributes lifetime income within the same generation*. While it is debatable whether or not social security *should* aim to redistribute income by itself, it is important to capture the magnitude of its *ex post* redistributive effects in order to design an overall structure of redistribution policies. On a lifetime basis, the benefit and premium/tax formula appears to redistribute income from those who earn more during their working years to those who earn less. This progressivity of the system, however, is naturally expected to be lower than observed on an annual basis, and to be difficult to measure.

In recent years, there have been a growing number of studies in the United States aiming to quantify the lifetime progressivity of the social security system using panel data, and to analyze its sensitivity to family or spousal features, mortality, and other heterogeneous factors. For example, Coronado, Fullerton, and Glass (2000) found that social security is much less progressive on a lifetime basis than on an annual basis, and quantified several individual characteristics that are relevant to determine the progressivity of social security. Gustman and Steinmeier (2001) pointed out that social security looks less progressive if individuals are grouped into households and adjusted for variations in secondary earner's income than it does when looking at retired worker benefits. Liebman (2002) emphasized that spouse benefits and differential mortality can offset a large part of the progressivity provided by the benefit formula. Furthermore, Coronado *et al.* (2002) conducted micro-simulations to compare the effects of several PAYGO reforms on the overall progressivity of the system.

In Japan, by contrast, it is very difficult to make a lifetime income-based analysis of intragenerational redistribution, because unlike in the United States, adequate panel data are unavailable. Based on a numerical analysis of a two-period life-cycle model, Shimono and Tachibanaki (1985) determined to what extent public pension programs redistribute lifetime income in Japan. They showed that a flat component of the pension benefits reduces the inequity of lifetime income and that an increase in a wage-proportional premium rate contributes to a reduction of income inequality. Takayama *et al.* (1990), who estimated the streams of lifetime income using micro-data from the 1994 National Survey on Consumption, first attempted to quantify the redistribution effects of the public pension programs across and within generations in Japan. They found that in older age groups, those with higher incomes receive greater net benefits, pointing to at least a partial regressivity of public pension programs. However, they neglected the "incompleteness" of the system; that is, the fact that social security benefits are covered not only by premiums but also by government subsidies (that are eventually financed by income and other taxes), as well as burdens postponed to future generations.

This paper focuses on Japan's public pension program, especially the *Kosei Nenkin* program for employed workers in the private sector, and attempts to measure its potential redistributive effects and progressivity on a lifetime basis using data from the 1996 Survey on the Redistribution of Income. Besides measuring the progressivity of the current system, we attempt to estimate the impacts of social security and tax reforms in terms of both efficiency and intragenerational equity in the long run. Due to limited information about each individual's earning's history, our analysis depends on artificially constructed streams of employees' lifetime incomes that are consistent with the actual income distribution on an annual basis shown in the Survey. Our analysis also concentrates on a steady state, in which each generation grows (shrinks) at the same fixed pace, and benefit payments are completely financed by premium and/or tax revenues at each time. This type of analysis cannot grasp the dynamics of income transfer across generations nor explicitly address intergenerational equity issues. We believe, however, that it can provide a basic picture of the potential progressivity and redistributive effect of social security on a lifetime basis within the same generation, which has tended to be ignored in Japan.

The remainder of the paper is organized as follows: In section **2** we first overview the redistributive feature of a PAYGO system on a lifetime basis using a simple two-period life-cycle model. Based on that model, we analyze to what extent it can be affected by social security and tax reforms, such as removing the maximum contribution ("cap"), levying income tax on benefits, and using consumption tax to finance them. In section **3** we empirically illustrate to what extent the *Kosei Nenkin* program is actually progressive on a lifetime basis using reorganized data from the Survey. We also conduct some policy simulations to analyze how much policy reforms can potentially affect net lifetime income on average and its distribution. Section **4** provides a conclusion and points out issues that remain to be addressed.

2. Theoretical Analysis

2.1 A simple model

Let us consider a very simple two-period, life-cycle model, in which one works in period 1 and retires in period 2, to roughly capture the redistributive feature of social security[1]. Assume that in period 1 one gets wage income (W) and pays a social security premium, which consists of a wage-proportional component (tW) and a flat component (T). And, in period 2 he or she receives a social security benefit, which consists of a wage-proportional component (bW) with a

[1] In this paper, we focus on public pension programs, ignoring other social security programs such as medical, long-term care, and employment insurance.

benefit multiplier (*b*) and a flat component (*B*). Hence, his or her net lifetime income (W^*) is generally expressed as

$$W^* = (1-t)W - T + \frac{bW + B}{1+r}, \tag{1}$$

where r is the interest rate. With no social security or under a funded system, net lifetime income is equal to gross income (W). For simplicity, we assume that W and r are exogenously given and fixed, and we also neglect inheritances and private transfers.

Under a PAYGO system, the government has to balance the social security premiums (paid by individuals who are in period 1) and its benefits (paid to individuals who are in period 2) at each time: that is,

$$(1+n)(t\overline{W} + T) = b\overline{W} + B,$$

where $\overline{W}$ is average wage income and n is rate of population growth. We assume a fixed rate of population growth. This assumption allows us to ignore issues related to intergenerational equity and concentrate on issues regarding (intergenerational) efficiency and intragenerational equity. We also assume that the level of a flat benefit (B) is exogenously determined for a certain policy target, such as guaranteeing a "minimum standard of living" for the elderly. Then, under a benefit-defined scheme, the rate of the wage-proportional premium is implicitly derived as[2]

$$t = \frac{1}{1+n}\left[b + \frac{B - (1+n)T}{\overline{W}}\right]. \tag{2}$$

It is widely recognized that a PAYGO system reduces net lifetime income if the population growth rate is lower than the interest rate, that is, if $n < r$. We can easily confirm this by substituting (2) into (1) to get

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[2] The main results of the following discussions hold on the assumption of a contribution-defined scheme.

$$\overline{W}^* = (1-t)\overline{W} - T + \frac{b\overline{W} + B}{1+r} = \overline{W} - \frac{(r-n)(b\overline{W} + B)}{(1+r)(1+n)} < \overline{W},\ if\ n < r \tag{3}$$

for an individual of average income. This suggests that in order to reduce the negative impact *of the system on lifetime income under an aging population the government should reduce* social security benefits ($b\overline{W} + B$); in other words, scale down the public pension program[3].

It should be noted, but is often ignored, that a PAYGO system can make net lifetime income more equally distributed than the gross one within the same generation. To show this, we rewrite *W** as

$$W^* = \left(1 - t + \frac{b}{1+r}\right)W - T + \frac{B}{1+r}, \qquad (1)'$$

which means that a PAYGO system can be interpreted as a life-cycle system of progressive income tax, as long as

$$\frac{b}{1+r} < t < 1 + \frac{b}{1+r} \text{ and } T < \frac{B}{1+r}.$$

Hence, a PAYGO system can reduce inequality in lifetime income. Indeed, the coefficient of variation (CV) of net lifetime income, which is often used to gauge the relative inequality of income around its average, is calculated as

$$CV(W^*) = \left[1 - \frac{(1+n)(B-(1+r)T)}{(1+r)(1+n)\overline{W} - (r-n)(b\overline{W} + B)}\right]CV(W), \tag{4}$$

where the denominator of the second term in parentheses has to be positive to make net lifetime income positive. Simple calculations can show that if $T < B/(1+r)$, that is, if an individual gets a positive flat benefit net over lifetime, introduction of a PAYGO system reduces

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[3] Breyer (1989), Geanakoplos, Mitchell and Zeldes (1998), Sinn (2000), and many others pointed out, however, that scaling down a PAYGO system (or shifting to a funded system) does not allow for a Pareto-improvement, taking into account the need to compensate the existing pension liabilities. The same type of problem should occur in the transition process for any kind of reform, but is *neglected in this paper.*

the relative inequality of lifetime income.

Then, what is the optimal PAYGO system in terms of both efficiency and intragenerational equity under an aging population, given the level of a flat benefit (*B*)? It is clear that a flat tax (*T*) should be zero, because it does not affect average net income, but increases its inequality, as seen from (3) and (4). What of the benefit multiplier (*b*)? Assuming that $n < r$, a larger value of *b* lowers the average net income (from (3)), but at the same time it reduces the CV (from (4)), because it requires a higher premium rate, which in turn adds to the progressivity of the system. Hence, the government will face a trade-off between efficiency and intragenerational equity: An efficiency- (intragenerational equity-) oriented government tends to choose a lower (higher) benefit multiplier. If the impact on the relative inequality of income is limited, however, the simplicity of the system?consisting of only a wage-proportional premium and a flat benefit?may look attractive.

If the government chooses this simple system, we can easily confirm that an individual with a lower income can get more net lifetime income than without a social security program, despite a reduction of average net lifetime income. Let us assume that *b*=0, *T*=0, and $t = B/\left[(1+n)t\overline{W}\right]$, making net lifetime income equal to

$$W^{*} = \left[1 - \frac{B}{(1+n)\overline{W}}\right]W + \frac{B}{1+r} = (1-t)W + \frac{(1+n)t\overline{W}}{1+r}. \tag{5}$$

Hence, while this PAYGO system reduces average net lifetime income under an aging population with $n < r$ because

$$\overline{W}^{*} = \overline{W} - \frac{(r-n)B}{(1+r)(1+n)} < \overline{W}, \tag{6}$$

it affects the net lifetime income of each individual differently in such a way that

$$W^{*} \geq W \text{ if } W \leq \frac{1+n}{1+r}\overline{W}; \quad W^{*} < W \text{ if } W > \frac{1+n}{1+r}\overline{W}.$$

This means individuals with lower incomes become better off at the expense of those with higher incomes under a PAYGO system[4].

In summary, a PAYGO system has a favorable effect on income redistribution, in that it reduces the degree of inequality relative to average income, despite its adverse impact on average lifetime income under an aging population. This is because the impact of a reduced variance of net lifetime income more than offsets the impact of its lowered average. However, two things should be noted: first, this redistributive effect decreases with lower population growth, which tends to reduce average net lifetime income and raise its relative inequality; second, the redistributive effect increases with a higher level of benefit, which requires a higher premium rate.

2.2 Annual vs. lifetime income redistribution

The social security system, managed under a PAYGO scheme, entails income transfer from the young to the old at each time. In this sense, it makes annual income more equally distributed as long as the actual earnings of the old are lower than those of the young. Because everyone experiences being both young and old in his or her life, however, income redistribution on an annual basis should be interpreted with caution.

This section illustrates the relationship between the redistributive effect of a PAYGO system on annual and lifetime income, with annual income meaning "period" income in our simple two-period life-cycle model. To address this issue clearly, we take an extreme case in which the interest rate and the population growth rate are both equal to zero. We also assume that the social security system has a simple structure consisting of only a wage-proportional premium and a flat benefit. In this extreme case, the average gross annual income for society

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[4] This discussion also suggests that there are some individuals who become worse off under a PAYGO system, even if the population growth rate exceeds the interest rate.

as a whole ($\overline{W}_a$) is equal to $\overline{W}/2$, because there are the same number of the young (who earn W) and the old (who earn no income). So, the variance of gross annual income is given by

$$V(W_a)=\frac{1}{2}\left(\overline{W}-\frac{\overline{W}}{2}\right)^2+\frac{1}{2}\left(0-\frac{\overline{W}}{2}\right)^2+\frac{V(W)}{2}=\frac{\overline{W}^2}{4}+\frac{V(W)}{2},$$

adding the inter-age group and intra-age group variances. Hence, the squared coefficient of the variance (SCV) of gross annual income is given by

$$SCV(W_a)=V(W_a)/\overline{W}_a^2=1+2SCV(W),$$

which is clearly larger than the SCV of gross lifetime income.

With the introduction of a PAYGO social security system, the net income of the young is $(1-t)W$ and that of the old is B, given the budget constraint per capita of $t\overline{W}=B$. Then, the average of net annual income ($\overline{W}_a^*$) remains the same as $\overline{W}/2$, and its variance is calculated in the same way as in the case of gross annual income:

$$V(W_a^*)=\frac{(1-2t)^2\overline{W}^2}{4}+\frac{(1-t)^2V(W)}{2}.$$

Then, the SCV of net annual income is

$$SCV(W_a^*)=V(W_a^*)/\overline{W}_a^{*2}=(1-2t)^2+2(1-t)^2SCV(W),$$

which is smaller than the SCV of gross annual income, because

$$SCV(W_a^*)-SCV(W_a)=-2t[2(1-t)+(2-t)SCV(W)]<0.$$

On the other hand, the SCV of net lifetime income is

$$SCV(W^*)=(1-t)^2SCV(W),$$

which is derived from (5) assuming $r=n$ and becomes clearly smaller than the SCV of gross lifetime income.

Now, let us compare the redistributive effects of the social security system on annual and lifetime income in terms of a change in the SCV:

$$\left|\frac{SCV(W_a^*)-SCV(W_a)}{SCV(W_a)}\right|-\left|\frac{SCV(W^*)-SCV(W)}{SCV(W)}\right|=\frac{t(2-3t)}{1+2SCV(W)}=\frac{B(2\overline{W}-3B)}{[1+2SCV(W)]\overline{W}^2}.$$

Thus, the redistributive effect of the social security system, if evaluated as a reduction in the SCV of annual income, tends to be overestimated unless the benefit is extremely high. This result appears to basically hold with more realistic assumptions for economic and demographic variables, as well as with social security schemes, as already confirmed by several empirical studies quoted in section 1.

2. 3 Equal treatment of two occupational groups

Next, let us discuss the plausibility of a pluralistic social security system, in which different schemes are applied to different occupational groups, before assessing the impact of policy reforms. The Japanese social security system basically consists of two schemes: one for employed workers (*Kosei Nenkin* and *Kyosai Kumiai*) and the other for self-employed workers (*Kokumin Nenkin*). The former scheme has a wage-proportional premium and a "double-decker" benefit, which consists of a wage-proportional component and a flat component. For the latter scheme, both the premium and the benefit are flat. The budget accounts of *Kosei Nenkin*, *Kyosai Kumiai*, and *Kokumin Nenkin* are connected with each other, and the level of the flat component is set to be the same for all schemes and is called *Kiso Nenkin* (Basic Pension Benefit). In addition, one third of the flat component is covered by the government subsidy, which is financed by income tax and other taxes[5].

Consider a two-group model, which roughly mirrors this Japanese social security system. Each individual belongs to either group 1, which pays a wage-proportional premium and receives a "double-decker" benefit, or group 2, which pays a flat premium and receives a flat

[5] The 2000 Pension Reform called for a rise in this subsidy ratio to 1/2 as of 2004.

benefit. Under this model, net lifetime income for each group is respectively given by

$$\text{Group 1: } W_1^* = (1-t-\tau)W_1 + \frac{bW_1 + B}{1+r}, \tag{7a}$$

$$\text{Group 2: } W_2^* = (1-\tau)W_2 - T + \frac{B}{1+r}, \tag{7b}$$

where τ is the rate of additional wage-proportional income tax that finances the government subsidy for the common flat benefit. We assume that this income tax is levied only on young workers. The budget constraint of the government is expressed as

$$(1+n)\left[\tau\left(\phi\overline{W}_1 + (1-\phi)\overline{W}_2\right) + \phi t\overline{W}_1 + (1-\phi)T\right] = \phi b\overline{W}_1 + B \tag{8}$$

with ϕ denoting the population share of group 1 members. Here, we assume that the budget constraints of two social security programs are integrated for society as a whole, reflecting the current scheme in Japan. The population size of each group is set to grow at the same n and no movement of members between groups is allowed. Assuming that θ*100% of B is covered by the government subsidy, we get the budget constraint for the flat benefit of

$$(1+n)\tau\left[\phi\overline{W}_1 + (1-\phi)\overline{W}_2\right] = \theta B,$$

which compresses (8) to

$$(1+n)\left[\phi t\overline{W}_1 + (1-\phi)T\right] = \phi b\overline{W}_1 + (1-\theta)B. \tag{8'}$$

Because the government has no reason to treat the two groups unequally, it has to make the formulae (7a) and (7b) effectively the same for any level of wage earnings. Because (7b) is rewritten as

$$W_1^* = (1-\tau)W_1 + \left(\frac{b}{1+r} - t\right)W_1 + \frac{B}{1+r},$$

one plausible way to do this is to arrange the premium and the benefit so that

$$t = \frac{b}{1+r}, \ T = 0.$$

If the government wants to maintain a wage-proportional premium for group 2 to finance the benefit for institutional reasons, this is the only arrangement that is available and desirable. Then, the budget constraint (8)' is

$$\phi(n-r)b\overline{W}_1 = (1-\theta)(1+r)B.$$

Because $n < r$ with an aging population and assuming $B > 0$, we obtain:

$$b = 0,\ \theta = 1,$$ [6]

which lead to $t = 0$. Therefore, both groups have to have only a common and flat benefit (*B*), and pay a wage-proportional premium with the common tax rate (τ), which is equivalent to the simple PAYGO system discussed in 2.1.

2.4 Redistributive impact of the "cap" system

The social security systems for employed workers in Japan?the *Kosei Nenkin* and *Kyosai Kumiai*?have an upper ceiling of wage earnings for calculating wage-proportional premiums and benefits, as observed in many other countries. This section analyzes the redistributive feature of this "cap" system. Denote *A* as the cap and divide the whole population into two income classes: a higher income class and a lower income class, with the income level of *A* as a threshold, then the net lifetime income of each class is given by

Higher-income class: $$W^* = W - t'A - T + \frac{B+bA}{1+r},\ \textit{if}\ W > A, \tag{9a}$$

Lower-income class: $$W^* = \left(1 - t' + \frac{b}{1+r}\right)W - T + \frac{B}{1+r},\ \textit{if}\ W \le A, \tag{9b}$$

where *t'* is a wage-proportional premium rate under the cap system. The budget constraint for society as a whole is expressed as

[6] This means that the Japanese two-group model with a partial government subsidy for the common flat benefit can be justified only under modest population growth with *n>r*.

$$(1+n)\left[\left(\varphi A+(1-\varphi)\overline{W}_-\right)t'+T\right]=\left[\varphi A+(1-\varphi)\overline{W}_-\right]b+B,$$

where φ is the population share of the higher-income class and assumed to be constant, and $\overline{W}_+$ ($\overline{W}_-$) is the average income of the higher income (lower income) group. With *B*, *T*, and *b* given exogenously, the premium rate is implicitly solved as

$$t'=\frac{1}{1+n}\left[b+\frac{B-(1+n)T}{\varphi A+(1-\varphi)\overline{W}_-}\right], \tag{10}$$

which can be shown to be higher than the premium rate (t) under a no-cap system that is given by (2), so long as $B>(1+n)T$.

How should this cap system be assessed in terms of efficiency and equity? It raises the average net lifetime income, because from (9a) and (9b) we get

$$\varphi\overline{W}_+^*+(1-\varphi)\overline{W}_-^*=\overline{W}^*+\frac{\varphi\left(\overline{W}_+^*-A\right)(r-n)b}{(1+n)(1+r)}>\overline{W}^*,$$

assuming $n<r$. However, the impact works asymmetrically on two income classes: it is favorable for a higher income class but not for a lower income class. It can be confirmed as follows. The average net lifetime income for the higher income class ($\overline{W}_+^*$) is higher than that under a no-cap system, because

$$\overline{W}_+^*-\left[\left(1-t+\frac{b}{1+r}\right)\overline{W}_+-T+\frac{B}{1+r}\right]=\frac{\overline{W}_+-A}{1+n}\left[\frac{(r-n)b}{1+r}+\frac{(1-\varphi)\overline{W}_-(B-(1+n)T)}{\overline{W}\left(A\varphi+(1-\varphi)\overline{W}_-\right)}\right]>0,$$

assuming $B>(1+n)T$ and $n<r$. For a lower income class, on the contrary, the average net lifetime income becomes lower, because

$$\overline{W}_-^*-\left[\left(1-t+\frac{b}{1+r}\right)\overline{W}_--T+\frac{B}{1+r}\right]=(t-t')\overline{W}_-<0.$$

Hence, the cap system is expected to widen the inter-group gap for net lifetime income compared to that under a no-cap system. This impact itself adds to the relative inequality of income distribution. Meanwhile, the intra-group variance of net lifetime changes in opposite directions for the two income classes: (9a) and (9b) suggest that for the higher income class the variance remains the same as the gross one, and is thus larger than net income without a cap, while the variance for the lower-income class is smaller than that without a cap due to a higher premium rate. Hence, the direction of a change in the redistribution effects is indeterminate[7].

2.5 Taxation

The Japanese system of income taxation is often criticized for being too generous to the elderly, who can enjoy several income exemptions for taxation. Actually, most pensioners do not need to pay any income tax on benefits. With a deterioration of social security finances in prospect, some argue for raising income tax on benefits or increasing consumption tax to hold down PAYGO burdens, which are currently levied exclusively on young people. Such tax policies are likely to reduce the adverse income transfer between generations and raise average net lifetime income with an aging population. Yet, it is uncertain whether or not it can reduce the inequality of lifetime income within the same generation.

Let us consider the system in which the government finances a flat social security benefit by a wage-proportional tax (with a tax rate t_i), which is commonly levied on both young and old people, and compare this case to the simple PAYGO system described in 2.1. The budget constraint per capita of the social security system will be expressed as

$$t_i\left[(1+n)\overline{W}+B\right]=B,$$

which is given from (1) setting T=b=0. Then, net lifetime income (W_i^*) is expressed as

$$W_i^*=(1-t_i)\left(W+\frac{B}{1+r}\right)=\left[1-\frac{B}{(1+n)\overline{W}+B}\right]\left(W+\frac{B}{1+r}\right) \qquad (11)$$

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[7] Shimono and Tachibanaki (1985)'s numerical analysis pointed out that removing the cap has a limited impact on income redistribution in Japan. Meanwhile, Coronado *et al.* (2000) showed that this type of reform makes the system less progressive in the United States.

The effects of this taxation are mixed. On the one hand, with the same level of benefit (B), average net income is higher than in the case with no tax on benefit. To show this, we compare (11) to (6):

$$\overline{W_i}^* = \left[1 - \frac{B}{(1+n)\overline{W} + B}\right]\left(\overline{W} + \frac{B}{1+r}\right) = \overline{W}^* + \frac{(r-n)B^2}{(1+r)(1+n)\left[(1+n)\overline{W} + B\right]} > \overline{W}^* \qquad (12)$$

assuming $n < r$. This result makes sense intuitively, because taxing the benefit spreads social security costs more widely among different generations, and mitigates intergenerational transfers with an aging population. On the other hand, the variance of net lifetime income becomes larger, because t_i is clearly lower than t and thus reduces the progressivity of the system. Putting these factors together, we get the coefficient of variance of net lifetime income, which is equal to

$$CV(W_i^*) = \frac{(1+r)\overline{W}}{(1+r)\overline{W} + B} CV(W). \qquad (13)$$

Besides, we can show that

$$\frac{CV(W_i^*)}{CV(W^*)} = \frac{(1+r)(1+n)\overline{W}^2 - (r-n)B\overline{W}}{(1+r)(1+n)\overline{W}^2 - (r-n)B\overline{W} - B^2} > 1,$$

which indicates that taxing the benefit reduces the redistributive effect of a PAYGO system within the same generation. Hence, income taxation on the benefit is desirable in terms of efficiency, but is undesirable in terms of intragenerational equity.

How will these results change when applying consumption tax, which is levied on consumption expenditures of both the young and old, instead of income tax to finance social security benefits? To answer this question, we take a simple case in which an individual consumes all of his or her net lifetime income leaving no bequest, and smoothes consumption over lifetime to maximize his or her utility. Denote consumption in periods 1 and 2 as C_1 and C_2, respectively, with a consumption tax rate of t_c, and assume that the lifetime utility function of an individual is expressed as

$$U(C_1, C_2) = \ln C_1 + \frac{1}{1+r} \ln C_2, \tag{14}$$

where the discount rate of utility in period 2 is assumed to be equal to the interest rate.

Then, on average for society as a whole consumption in each period is given as:

$$\overline{C}_1 = \overline{C}_2 = \frac{1+r}{(1+t_c)(2+r)}\left(\overline{W} + \frac{B}{1+r}\right)$$

and considering that the budget constraint of the social security system is given by

$$t_c\left[(1+n)\overline{C}_1 + \overline{C}_2\right] = B,$$

the consumption tax rate is implicitly solved as

$$\frac{t_c}{1+t_c} = \frac{B(2+r)/(2+n)}{\left[(1+r)\overline{W} + B\right]}.$$

Hence, net lifetime income (W_c^*) is given by

$$W_c^* = \frac{1}{1+t_c}\left(W + \frac{B}{1+r}\right) = \left[1 - \frac{B(2+r)/(2+n)}{(1+r)\overline{W} + B}\right]\left(W + \frac{B}{1+r}\right) \tag{15}$$

and its average is calculated as

$$\overline{W}_c^* = \left[1 - \frac{B(2+r)/(2+n)}{(1+r)\overline{W} + B}\right]\left(\overline{W} + \frac{B}{1+r}\right) = \overline{W}^* + \frac{(r-n)B}{(1+r)(1+n)(2+n)} > \overline{W}^*. \tag{16}$$

Comparing this with (12), we get

$$\overline{W}_c^* = \overline{W}_i^* + \frac{(r-n)B(\overline{W} - B)}{(1+r)(2+n)\left[(1+n)\overline{W} + B\right]} > \overline{W}_i^*$$

assuming $n < r$ and $B < \overline{W}$. Hence, consumption tax becomes more efficient than wage-proportional income tax with an aging population, as long as the social security benefit is lower than wage earnings. This is because in period 2 an individual consumes more than the benefit, and thus pays more (consumption) tax than in the case of income tax, which is levied not on the benefit but on consumption expenditures. Thus, consumption tax can suppress income transfer from the young to the old under an aging population more effectively than income tax.

Meanwhile, as seen in (16), net lifetime income is proportional to the sum of wage and present discounted value of the benefit, as in the case of income taxation on the benefit (see (11)). Thus, these two types of taxation have the same CV of net lifetime income, which is expressed in (13). Therefore, under an aging population, consumption tax is superior to income tax for financing a social security benefit, because it leads to a smaller reduction in average net lifetime income without increasing the relative inequality of lifetime income.

This assessment of consumption tax, however, would be affected by introducing "price indexation," which automatically raises the level of benefit (as well as after-tax consumer prices) by as much as the consumption tax rate. Starting with no consumption tax, the benefit is inflated to $(1+t_{cc})B$, where t_{cc} is a modified consumption tax rate at an equilibrium. Thus, the budget constraint of the social security system is given by

$$t_{cc}\left[(1+n)\overline{C}_1+\overline{C}_2\right]=(1+t_{cc})B,$$

and the consumption tax rate is implicitly solved as the value that satisfies

$$\frac{t_{cc}}{1+t_{cc}}=\frac{(1+t_{cc})B(2+r)/(2+n)}{\left[(1+r)\overline{W}+(1+t_{cc})B\right]}, \tag{17}$$

assuming the individual's utility function (14). This modified consumption tax rate can easily be shown to be higher than the consumption tax rate with no price indexation (t_c), because the government has to finance the benefit inflated by price indexation. Net lifetime income (W_{cc}^*) and its average are given respectively by

$$W_{cc}^*=\frac{1}{1+t_{cc}}\left[W+\frac{(1+t_{cc})B}{1+r}\right]=\left[1-\frac{(1+t_{cc})B(2+r)/(2+n)}{(1+r)\overline{W}+(1+t_{cc})B}\right]\left[W+\frac{(1+t_{cc})B}{1+r}\right], \tag{18}$$