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Appendix A: A reduced form model for the costs of childcare.

For the analysis of the impact of child care subsidies on labor participation, we used a reduced form model, which has been estimated using data from the OSA Labour supply panel 2000. The costs of childcare have been determined in six steps:

1. A logit model that indicates whether mothers with children of 0 to 3 years of age make use of childcare has been estimated.
2. An OLS-model for the number of daily periods has been estimated for mothers with children of 0 to 3 years of age that make use of childcare.
3. A logit model that indicates whether mothers with children of 4 to 12 years of age make use of childcare has been estimated.
4. An OLS-model for the number of daily periods has been estimated for mothers with children of 4 to 12 years of age that make use of childcare.
5. A logit model that indicates whether it concerns paid childcare has been estimated.
6. An OLS model for the amount of childcare costs has been estimated.

The model results can be found below.

1. Logit model for childcare for children aged 0-3

Number of obs = 255
LR chi2(5) = 122.29
Log likelihood = -115.59188
Pseudo R2 = 0.3460

Variable	Coefficient	Standard error	t-value
h_f	0.235	0.037	6.42
$h_f * h_f$	-0.004	0.00093	-4.37
# ch 0412	-0.463	0.162	-2.86
Edl4f	1.102	0.392	2.81
Edl5f	2.582	1.183	2.18
Constant	-1.674	0.386	-4.33

h_f is the number of hours worked by the mother; # ch04 is the number of children aged 4 to 12 years; Edl4f (Edl5f) is a dummy variable that equals one if the mother has finished vocational colleges (university).

2. Number of daily periods childcare (0-3 years)

Number of obs = 129
F(1,127) = 18.94
Adj R-squared =0.1229
Root MSE = 1.8971

Variable	Coefficient	Standard error	t-value
h_f	0.069	0.016	4.35
Constant	2.484	0.370	6.71

3. Logit model for childcare for children aged 4-12

Number of obs = 490
LR chi2(5) = 144.53
Log likelihood = -181.02196
Pseudo R2 = 0.2853

Variable	Coefficient	Standard error	t-value
h_f	0.100	0.021	4.78
$h_f * h_f$	-0.00086	0.00037	-2.34
Edl4f	0.632	0.268	2.36
Age yng child (B)	0.934	0.211	4.42
B * B	-0.073	0.015	-4.87
Uses ch care 0-3	2.831	0.524	5.41
Constant	-5.534	0.770	-7.18

h_f is the number of hours worked by the mother; Edl4f is a dummy variable that equals one if the mother has finished vocational colleges; Age yng child is the age of the youngest child; Uses ch care 0-3 is a dummy variable that equals one if the mother makes use of childcare for children aged 0-3 years.

4. Number of daily periods childcare (4-12 years)

Number of obs = 118
F(1,116) = 19.92
Adj R-squared =0.1392
Root MSE = 1.6735

Variable	Coefficient	Standard error	t-value
h_f	0.054	0.012	4.46
Constant	1.291	0.328	3.93

5. Logit paid childcare (if childcare)

Number of obs = 201
LR chi2(5) = 38.76
Log likelihood = -87.507536
Pseudo R2 = 0.1813

Variable	Coefficient	Standard error	t-value
Uses ch care 0-3 (a)	0.325	0.129	2.53
Uses ch care 4-12 (b)	0.392	0.205	1.91
(a) * (b)	-0.118	0.0146	-2.55
h_f	0.054	0.021	2.50
Edl45	1.559	0.460	3.39
Constant	-1.259	0.538	-2.34

Uses ch care 0-3 is a dummy variable that equals one if the mother makes use of childcare for children aged 0-3 years; Uses ch care 4-12 is a dummy variable that equals one if the mother makes use of childcare for children aged 4-12 years; h_f is the number of hours worked by the mother; Edl45f is a dummy variable that equals one if the mother has done vocational colleges or university.

6. Costs of childcare (if paid childcare)

Number of obs = 156
F(3,152) = 27.55
Adj R-squared =0.3395
Root MSE = 366.16

Variable	Coefficient	Standard error	t-value
Uses ch care 0-3 (a)	108.56	14.73	7.37
Uses ch care 4-12 (b)	175.16	21.07	8.31
(a) * (b)	-25.74	6.15	-4.19
Constant	-32.15	62.14	-0.52

Uses ch care 0-3 is a dummy variable that equals one if the mother makes use of childcare for children aged 0-3 years; Uses ch care 4-12 is a dummy variable that equals one if the mother makes use of childcare for children aged 4-12 years.

Appendix B:

Single decision makers: men

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Age	30.99 (11.90)	31.56 (11.88)	32.39 (12.32)	32.89 (12.95)	32.87 (12.75)	31.92 (12.69)	32.58 (12.84)	32.35 (12.52)	32.90 (13.08)	33.65 (13.09)	33.74 (13.41)
Edl1	0.223	0.257	0.192	0.200	0.162	0.126	0.122	0.113	0.086	0.084	0.083
Edl2	0.258	0.235	0.242	0.253	0.258	0.263	0.254	0.226	0.240	0.208	0.210
Edl3	0.372	0.338	0.379	0.386	0.389	0.373	0.400	0.423	0.437	0.495	0.452
Edl4	0.103	0.101	0.120	0.103	0.117	0.128	0.157	0.152	0.149	0.134	0.149
Edl5	0.044	0.048	0.055	0.040	0.034	0.056	0.059	0.066	0.068	0.060	0.068
Edl6	0.000	0.020	0.013	0.017	0.040	0.054	0.008	0.020	0.020	0.019	0.037
Wage rate	21.48 (10.33) N=294	22.90 (11.30) N=271	24.04 (20.49) N=278	23.33 (11.87) N=284	21.62 (9.99) N=256	21.09 (9.14) N=272	21.69 (11.61) N=273	21.30 (11.27) N=282	19.54 (12.53) N=344	20.25 (10.34) N=323	20.92 (9.27) N=293
h_m N=	37.04 (5.91) 394	37.11 (5.29) 342	37.15 (5.09) 369	37.04 (5.96) 340	36.80 (6.56) 313	36.43 (7.32) 376	36.80 (6.00) 344	36.71 (5.93) 333	36.84 (5.12) 355	36.60 (6.21) 329	35.82 (6.86) 325
Single parent	0.058	0.040	0.044	0.042	0.040	0.044	0.055	0.052	0.041	0.029	0.046
Living at parent	0.459	0.426	0.400	0.420	0.420	0.429	0.390	0.410	0.362	0.371	0.377
# ch 0-17	1.333 N=12	1.300 N=10	1.529 N=17	1.471 N=17	1.667 N=9	1.533 N=15	1.500 N=16	1.167 N=12	1.500 N=10	1.500 N=10	1.300 N=10
D child 0-5	0.002	0.000	0.004	0.008	0.002	0.004	0.002	0.005	0.002	0.002	0.002
N	503	455	475	474	445	499	477	442	442	418	409

Single decision makers: women

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Age	36.40 (15.04)	36.96 (14.96)	37.21 (14.36)	37.29 (14.31)	37.74 (14.39)	37.74 (14.31)	38.22 (14.13)	39.32 (13.87)	38.69 (14.19)	39.07 (14.06)	38.67 (14.23)
Edl1	0.288	0.284	0.209	0.206	0.176	0.135	0.148	0.135	0.132	0.124	0.108
Edl2	0.234	0.255	0.261	0.286	0.302	0.268	0.241	0.227	0.220	0.240	0.235
Edl3	0.324	0.312	0.337	0.333	0.340	0.386	0.389	0.409	0.396	0.391	0.398
Edl4	0.120	0.122	0.159	0.143	0.133	0.146	0.176	0.177	0.194	0.183	0.180
Edl5	0.034	0.025	0.033	0.030	0.031	0.037	0.038	0.036	0.041	0.041	0.044
Edl6	0.000	0.002	0.002	0.002	0.018	0.028	0.007	0.016	0.017	0.021	0.035
Wage rate	20.42 (10.60) N=284	24.98 (31.14) N=274	22.92 (11.67) N=274	21.98 (9.97) N=302	21.32 (10.93) N=307	20.83 (10.61) N=321	21.22 (12.38) N=308	23.85 (21.98) N=282	19.97 (10.80) N=366	20.80 (9.33) N=350	22.47 (15.91) N=331
h_f N=	33.15 (9.80) 369	33.11 (9.01) 346	32.71 (9.45) 358	32.85 (9.71) 362	32.80 (9.27) 350	32.04 (9.74) 416	32.43 (9.01) 363	31.22 (9.43) 351	31.96 (8.58) 375	31.69 (8.84) 363	31.23 (8.91) 393
Single parent	0.169	0.165	0.179	0.173	0.158	0.163	0.171	0.186	0.190	0.208	0.191
Living at parent	0.260	0.241	0.210	0.206	0.208	0.233	0.208	0.184	0.189	0.195	0.221
# ch 0-17	1.664 N=110	1.629 N=97	1.495 N=109	1.548 N=104	1.639 N=97	1.562 N=105	1.534 N=103	1.553 N=103	1.649 N=111	1.658 N=117	1.630 N=108
D child 0-5	0.045	0.042	0.051	0.050	0.034	0.040	0.043	0.038	0.043	0.046	0.041
N	649	589	609	601	615	645	601	555	583	563	566

Joint decision makers: men

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Age	40.01 (10.28)	40.26 (10.16)	40.40 (9.96)	40.41 (9.84)	41.15 (9.81)	41.22 (9.64)	41.55 (9.51)	41.94 (9.62)	42.22 (9.69)	42.27 (9.54)	42.64 (9.64)
Edl1	0.230	0.222	0.122	0.120	0.095	0.086	0.088	0.068	0.058	0.049	0.040
Edl2	0.188	0.183	0.191	0.195	0.189	0.174	0.168	0.161	0.159	0.153	0.143
Edl3	0.397	0.400	0.456	0.452	0.460	0.455	0.481	0.487	0.479	0.486	0.485
Edl4	0.136	0.139	0.167	0.172	0.170	0.181	0.185	0.192	0.205	0.206	0.217
Edl5	0.049	0.052	0.060	0.058	0.061	0.066	0.073	0.075	0.082	0.088	0.093
Edl6	0.001	0.004	0.003	0.004	0.025	0.038	0.005	0.016	0.016	0.018	0.021
Wage rate N=	30.24 (25.68) 1654	32.57 (44.62) 1595	31.66 (20.16) 1715	30.24 (13.60) 1760	28.27 (11.42) 1740	29.11 (17.60) 1708	28.37 (13.92) 1730	29.74 (32.89) 1707	29.20 (17.48) 1733	29.29 (15.60) 1697	30.03 (14.82) 1636
h_m N	37.88 (4.26) 1847	37.86 (4.50) 1798	37.89 (4.32) 1909	37.93 (4.18) 2013	38.21 (4.59) 1870	38.18 (4.30) 1881	38.19 (4.18) 1877	37.98 (4.29) 1800	37.86 (4.37) 1752	37.90 (4.25) 1724	38.03 (3.89) 1702

Joint decision makers: women

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Age	37.62 (10.25)	37.89 (10.19)	37.94 (10.00)	38.03 (9.90)	38.81 (14.39)	38.90 (9.66)	39.25 (9.58)	39.66 (9.67)	39.92 (14.19)	39.98 (9.59)	40.28 (9.70)
Edl1	0.246	0.239	0.184	0.170	0.139	0.129	0.120	0.104	0.095	0.070	0.066
Edl2	0.300	0.289	0.287	0.291	0.276	0.258	0.255	0.237	0.227	0.219	0.205
Edl3	0.335	0.346	0.387	0.390	0.400	0.408	0.446	0.452	0.465	0.478	0.478
Edl4	0.107	0.110	0.124	0.130	0.137	0.143	0.150	0.155	0.163	0.175	0.184
Edl5	0.011	0.012	0.015	0.016	0.019	0.023	0.027	0.032	0.032	0.046	0.052
Edl6	0.000	0.004	0.003	0.003	0.029	0.038	0.002	0.019	0.018	0.011	0.015
Wage rate N=	21.81 (10.87) 761	23.94 (37.75) 807	23.00 (16.31) 970	23.58 (27.28) 1056	21.78 (12.87) 1130	21.75 (16.69) 1109	23.02 (23.57) 1152	22.12 (16.47) 1171	21.40 (11.91) 1197	22.17 (12.94) 1212	23.83 (13.88) 1005
h_f N=	24.49 (11.69) 954	24.31 (11.49) 993	24.06 (11.55) 1157	23.96 (11.46) 1198	23.78 (11.17) 1246	23.82 (11.12) 1269	23.27 (10.91) 1301	23.87 (10.87) 1274	23.62 (10.48) 1251	23.97 (10.31) 1263	23.85 (10.31) 1294

Joint decision makers: men and women

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
# kids 0-3	1.511 N=454	1.446 N=363	1.521 N=470	1.508 N=459	1.527 N=404	1.508 N=413	1.541 N=386	1.545 N=387	1.529 N=395	1.546 N=377	1.557 N=359
# kids 4-12	1.599 N=753	1.629 N=700	1.650 N=754	1.654 N=772	1.661 N=760	1.680 N=726	1.682 N=723	1.674 N=666	1.641 N=640	1.620 N=631	1.596 N=631
# kids 12-17	1.293 N=427	1.319 N=408	1.333 N=423	1.338 N=423	1.293 N=440	1.315 N=448	1.337 N=451	1.384 N=437	1.344 N=436	1.365 N=405	1.370 N=376
# ch <17 N=	1.933 1203	1.904 1096	1.947 1238	1.978 1225	1.955 1193	1.917 1208	1.943 1183	1.944 1133	1.924 1104	1.919 1064	1.913 1027
Age yng child<12	4.67 N=972	4.71 N=918	4.72 N=995	4.86 N=1004	5.13 N=968	4.95 N=971	5.08 N=944	4.95 N=892	4.86 N=868	4.94 N=839	5.03 N=832
D ch 0-5	0.275	0.244	0.273	0.272	0.255	0.265	0.250	0.247	0.253	0.254	0.257
N	2110	2025	2172	2163	2140	2117	2104	2015	1940	1900	1861

All

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Unempl. rate	6.6	6.2	6.3	7.3	8.2	7.8	7.2	6.2	4.9	4.0	3.6
Economic climate	1.0	0.9	0.1	-2.1	-1.2	0.5	-0.4	0.2	1.2	0.3	0.9

IV.　研究成果の刊行に関する一覧表

IV. 研究成果の刊行に関する一覧表

書籍

著者氏名	論文タイトル名	書籍全体の編集者名	書籍名	出版社名	出版地	出版年	ページ
佐藤俊樹		佐藤俊樹	『００年代の格差ゲーム』	中央公論新社		2002年	
橘木俊詔・大田弘子・佐藤俊樹・蓼沼宏一	「日本は不平等化してよいのか・よくないのか：パネル・ディスカッション」	大塚啓二郎・中山幹夫・福田慎一・本多佑三編	『現代経済学の潮流2002』	東洋経済新報社		2002年	
田近栄治・古谷泉生	「税制改革のマイクロ・シミュレーション分析」	小野善康・中山幹夫・福田慎一・本多佑三編	『現代経済学の潮流2003』	東洋経済新報社.		2003年	
阿部　彩・大石亜希子	「母子世帯の経済状況と社会保障」	国立社会保障・人口問題研究所編	『子育て世帯の社会保障』	東京大学出版会		2005年	

雑誌

発表者名	論文タイトル名	発表誌名	巻名	ページ	出版年
Takashi Oshio	"Social Security and Intragenerational Redistribution of Lifetime Income in Japan"	一橋大学世代間利害調整プロジェクト（特定領域研究）ディスカッション・ペーパー	No.172		2003年
佐藤俊樹	「不平等社会のゆくえと共同の論理「弱者」から「敗者」へ」	『生活経営学研究』	第38巻	pp.3-7.	2003年
大石亜希子	「有配偶女性の労働供給と税制・社会保障制度」	『季刊社会保障研究』	第39巻第3号	pp.286-300.	2003年

阿部　彩	「アメリカ福祉改革の効果と批判」	『海外社会保障研究』	第147号	pp.68-76.	2004年
小塩隆士	「1990年代における所得格差の動向」	『季刊社会保障研究』	第40巻第3号	pp.277-285.	2004年
Oshio, Takashi	"Social Security and the Intragenerational Redistribution of Lifetime Income in Japan"	*The Japanese Economic Review*	Vol.56, No.1	pp.85-106.	2005年
稲垣誠一	「若年フリーター増加がもたらす将来の人口構造への影響（ミクロシミュレーションモデルによる人口の将来推計）」	『人口学研究』	（投稿中）		

V.　研究成果の刊行物・別刷

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SOCIAL SECURITY AND THE INTRAGENERATIONAL REDISTRIBUTION OF LIFETIME INCOME IN JAPAN*

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We investigate how social security redistributes lifetime income within the same generation in Japan, based on data from the micro data. The progressivity of Japan's state pension programme appears to be much more limited on a lifetime basis than on an annual basis. Given an ageing 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.
JEL Classification Numbers: H55, H23.

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 state pension programmes, is sometimes assessed from two viewpoints. First, with a rapidly ageing population, a PAYGO system is likely to entail substantial income transfers across generations and to reduce the net lifetime incomes of young and future generations. There have been many attempts to address empirically the issues of intergenerational redistribution and inequality by selecting a representative individual of each generation. Hatta *et al.* (1998) and Takayama *et al.* (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 as a result of 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 the premiums and taxes. Indeed, the Ministry of Health, Labour 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 both young and old in his or her lifetime. 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

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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. From 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 programme 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 have earned 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 analyse its sensitivity to family or spousal features, mortality and other heterogeneous factors. For example, Coronado *et al.* (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 workers' 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. On the basis of a numerical analysis of a two-period life-cycle model, Shimono and Tachibanaki (1985) determined the extent to which state pension programmes 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 in 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 state pension programmes across and within generations in Japan. They found that in older age groups those with higher incomes are receiving greater net benefits, pointing to at least a partial regressivity of state pension programmes. However, they neglected the "incompleteness" of the system, i.e. the fact that social security benefits are covered not only by premiums but also by government subsidies (which are eventually financed by income and other taxes), as well as by burdens postponed to future generations.

This paper focuses on Japan's state pension programme, especially the Kosei Nenkin programme 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. Owing to limited information about each individual's earnings 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 or 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, something that has tended to be ignored in Japan.

The remainder of the paper is organized as follows. Section 2 first overviews the redistributive feature of a PAYGO system on a lifetime basis using a simple two-period life-cycle model. Using that model, we analyse the extent to which it can be affected by tax reforms such as the imposition of income tax on benefits, and the use of consumption tax to finance them. Section 3 illustrates empirically the extent to which the Kosei Nenkin programme is actually progressive on a lifetime basis using reorganized data from the Survey. We also conduct some policy simulations to analyse how much policy reforms could 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 capture roughly 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). Then in period 2 the individual receives a social security benefit, which consists of a wage-proportional component (bW) with a benefit multiplier (b) and a flat component (B). Hence, the individual's 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.

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 $n < r$.[2] It should be noted, but is often ignored, that a PAYGO system can make net lifetime income more equally distributed than the gross lifetime income within the same generation. To show this, we rewrite W^* as

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

[2] However, Breyer (1989), Geanakoplos *et al.* (1998), Sinn (2000) and many others have pointed out that a scaling-down of a PAYGO system (or a shift 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.

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

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

$$0 < t - \frac{b}{1+r} < 1 \quad \text{and} \quad T < \frac{B}{1+r}.$$

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

$$CV(W^*) = \left[1 - \frac{(1+n)(B-(1+r)T)}{(1+r)(1+n)\bar{W} - (r-n)(b\bar{W}+B)}\right]CV(W), \tag{2}$$

where $\bar{W}$ is average income and n is a rate of population growth, considering the government's budget constraint: $(1+n)(t\bar{W}+T) = b\bar{W}+B$. 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 the relative inequality of lifetime income.

What, then, is the optimal PAYGO system in terms of both efficiency and intragenerational equity for an ageing 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 (2). What of the benefit multiplier (b)? Assuming that a larger value of b lowers the average net income, at the same time it reduces the CV (from (2)), 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 inequality of income is relatively 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 programme, despite a reduction in average net lifetime income. Let us assume that $b = 0$, $T = 0$ and $t = B/[(1+n)t\bar{W}]$, making net lifetime income equal to

$$W^* = \left[1 - \frac{B}{(1+n)\bar{W}}\right]W + \frac{B}{1+r} = (1-t)W + \frac{(1+n)t\bar{W}}{1+r}. \tag{3}$$

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

$$\bar{W}^* = \bar{W} - \frac{(r-n)B}{(1+r)(1+n)} < \bar{W}, \tag{4}$$

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

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

This means individuals with lower incomes become better off at the expense of those with higher incomes under a PAYGO system.[3]

To sum up, a PAYGO system has a favourable 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 ageing 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 *v.* 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 lifetime, 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, I take an extreme case in which the interest rate and the population growth rate are both equal to zero. I 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 as a whole ($\bar{W}_a$) is equal to $\bar{W}/2$, 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

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

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

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

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 $t\bar{W} = B$. Then the average of net annual income ($\bar{W}_a^*$) remains the same as $\bar{W}/2$, and its variance is calculated in the same way as in the case of gross annual income:

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

[3] 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.

Then, the SCV of net annual income is

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

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

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

which is derived from (3) assuming that $r = n$, 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:

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

It can be seen that 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 hold basically with more realistic assumptions for economic and demographic variables, as well as for social security schemes, as already confirmed by several empirical studies quoted in Section 1.

2.3 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. In fact, most pensioners do not have to pay any income tax on benefits. With a deterioration of social security finances in prospect, some argue for the raising of income tax on benefits or an increase in the 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 the generations and to raise average net lifetime income with an ageing 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 with the simple PAYGO system described in Section 2.1. The budget constraint per capita of the social security system will be expressed as

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

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

$$W_i^* = (1 - t_i)\left(W + \frac{B}{1 + r}\right) = \left[1 - \frac{B}{(1 + n)\bar{W} + B}\right]\left(W + \frac{B}{1 + r}\right). \quad (5)$$

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 (5) with (4):

$$\bar{W}_i^* = \left[1 - \frac{B}{(1+n)\bar{W} + B}\right]\left(\bar{W} + \frac{B}{1+r}\right) = \bar{W}^* + \frac{(r-n)B^2}{(1+r)(1+n)[(1+n)\bar{W} + B]} > \bar{W}^*, \quad (6)$$

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 ageing 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

$$CV(W_i^*) = \frac{(1+r)\bar{W}}{(1+r)\bar{W} + B} CV(W). \quad (7)$$

In addition, we can show that

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

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 undesirable in terms of intragenerational equity.

How will these results change when applying consumption tax, which is levied on the consumption expenditures of both the young and old, instead of income tax, to finance social security benefits? Let us take a simple case in which an individual consumes all of his net lifetime income leaving no bequest, and smoothes consumption over his lifetime to maximize his 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

$$U(C_1, C_2) = \ln C_1 + \frac{1}{1+r} \ln C_2, \quad (8)$$

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

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

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

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

the consumption tax rate is implicitly solved as

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

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

$$W_c^* = \frac{1}{1+t_c}\left(W + \frac{B}{1+r}\right) = \left[1 - \frac{B(2+r)/(2+n)}{(1+r)\bar{W} + B}\right]\left(W + \frac{B}{1+r}\right) \quad (9)$$

and its average is calculated as

$$\bar{W}_c^* = \left[1 - \frac{B(2+r)/(2+n)}{(1+r)\bar{W} + B}\right]\left(\bar{W} + \frac{B}{1+r}\right) = \bar{W}^* + \frac{(r-n)B}{(1+r)(1+n)(2+n)} > \bar{W}^*. \quad (10)$$

Comparing this with (6), we get

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

assuming $n < r$ and $B < \bar{W}$.

Hence consumption tax becomes more efficient than wage-proportional income tax with an ageing 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 ageing population more effectively than income tax.

Meanwhile, as seen in (10), 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 (6)). Thus, these two types of taxation have the same CV of net lifetime income, which is expressed in (7). Under an ageing population, therefore, 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

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

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

$$\frac{t_{cc}}{1 + t_{cc}} = \frac{(1 + t_{cc})B(2+r)/(2+n)}{[(1+r)\bar{W} + (1+t_{cc})B]}, \quad (11)$$

assuming the individual's utility function (8). 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

$$W_{cc}^* = \frac{1}{1+t_{cc}}\left[W + \frac{(1+t_{cc})B}{1+r}\right] = \left[1 - \frac{(1+t_{cc})B(2+r)/(2+n)}{(1+r)\bar{W} + (1+t_{cc})B}\right]\left[W + \frac{(1+t_{cc})B}{1+r}\right], \quad (12)$$

$$\bar{W}_{cc}^* = \bar{W}^* + \frac{(r-n)B[1 - (1+n)t_{cc}]}{(1+r)(2+n)},$$

the latter of which leads to $\bar{W}_{cc}^* > \bar{W}^*$, provided the consumption tax rate is lower than $1/(1 + n)$, and also to $\bar{W}_{cc}^* < \bar{W}_c^*$ from (10). It is, however, indeterminate whether or not $\bar{W}_{cc}^* > \bar{W}_i^*$, because a higher benefit requires a higher consumption tax, which in turn raises its rate via price indexation of the benefit.[4] Meanwhile, the CV of net lifetime income is given by

$$CV(W_{cc}^*) = \frac{(1+r)\bar{W}}{(1+r)\bar{W} + (1+t_{cc})B} CV(W),$$

which is lower than that in the case of income taxation or consumption tax without price indexation (see (7)). However, we can show that consumption tax with price indexation cannot reduce the CV of net lifetime income from the level with no taxation on the benefit, as far as $n < r$. Consumption tax, if price-indexed, makes both the benefit and the tax rate higher, which adds to the progressivity of consumption tax, but this effect is more than offset by a reduction of net lifetime income with an ageing population.

In sum, the analysis in this section concludes that:

1. income tax on the benefit makes average net lifetime income higher than in the case of no taxation on the benefit, while it widens its relative inequality within the same generation;
2. consumption tax with no price indexation is preferable to income tax, in that the former makes average net lifetime income higher than the latter, while these two tax policies lead to the same relative inequality of income distribution;
3. consumption tax with price indexation makes average net lifetime income lower than consumption tax with no price indexation and possibly lower than income tax (but still higher than in the case of no taxation on the benefit), while it makes net lifetime income more equally distributed than those two types of taxation.

Discussions in this section apply to a simple social security system that has only a flat benefit and a wage-proportional premium as a baseline, but the key messages are likely to hold with a more realistic system.

3. Empirical analysis

3.1 Measurement of redistributive effects and progressivity

It is almost impossible to measure directly the impact of social security programmes on lifetime income in Japan, because no panel data are available that provide a profile of wage income, social security contributions and benefits. Our analysis thus depends heavily on cross-section data of the 1996 Survey on the Redistribution of Income, which was conducted and published by the Ministry of Health and Welfare (which is now the Ministry of Health, Labour and Welfare). The Survey reports an individual's wage, social security contributions and benefits, and income and other taxes plus her family, spouse and occupational characteristics in the survey year, but no longitudinal information is available.

[4] Simple calculations show that a higher benefit makes average net lifetime income lower provided $r > n$, and that it is necessary for the tax and the benefit to satisfy the condition $B < [1-(1+n)t_{cc}]\bar{W}/(1+t_{cc})$ in order to make $\bar{W}_{cc}^* > \bar{W}_i^*$. This condition can be simplified to $B < W/3$ if $n = r = 0$, implying that a consumption tax with price indexation is more efficient than an income tax if the level of social security benefit is relatively low. This condition becomes stricter with an ageing population.

There are several ways to evaluate the overall redistributive effects and progressivity of the system. In this paper we use three measures. First, we calculate a change in the SCV, for which a larger reduction means greater redistribution of income. The SCV is useful in that its change can be easily decomposed as:

$$\frac{SCV(W^*) - SCV(W)}{SCV(W)} = \frac{1}{V(W)}\sum_i \omega_i[(\bar{W}_i^* - \bar{W}^*)^2 - (\bar{W}_i - \bar{W})^2] + \frac{1}{V(W)}\sum_i \omega_i[V(W_i^*) - V(\bar{W}_i)] + \frac{\bar{W}^2 - \bar{W}^{*2}}{\bar{W}^{*2}}\frac{V(W^*)}{V(W)},$$

where ω_i is a share of each group of a society. The first and second terms of the right-hand side indicate changes in the intragroup and intergroup variances, respectively, of income arising from a redistribution by the social security system. The third term shows the degree of "incompleteness" of income redistribution, which Oshio (2002) discussed in more detail. The social security system is usually incomplete in terms of income redistribution, in that its benefits are covered not only by employees' own contributions, but also employers' contributions and government subsidy (which is eventually to be financed by tax), making the average net income higher than gross income, and thereby lowering the SCV.[5] We have to take into account this incompleteness in order to assess redistribution policies precisely.

Second, we compare the Gini indices before and after social security taxes and benefits. The progressivity can be gauged by the "effective progression" (EP) measure of Musgrave and Thin (1948), also used by Coronado *et al.* (2000) and others:

$$EP = \frac{1 - Gini_{AT}}{1 - Gini_{BT}},$$

where $Gini_{AT}$ and $Gini_{BT}$ are before-tax-and-benefit and after-tax-and-benefit Gini indices. A value of one indicates that $Gini_{AT}$ and $Gini_{BT}$ are the same, and that social security has no impact on income distribution. A value greater than one indicates progressivity of the system, while a value less than one indicates regressivity of the system.

Third, we compare the magnitude of the net social security tax by income class. The net social security tax rate is defined as the magnitude of the difference between the present discounted value of premiums or taxes paid and benefits received, relative to gross lifetime income. If higher income individuals face a higher net social security tax rate, we can conclude that the system is progressive. I focus on this tax rate when assessing the redistributive impact of policy reforms in Section 3.4.

First, let us provide a rough picture of income redistribution through the social security system as a whole—including all members of Kosei Nenkin, Kyosai Kumiai and Kokumin Nenkin—on an annual basis. Table 1(a) summarizes income redistribution through the social security programmes as a whole, based on all individuals classified into two age groups: the young (aged 20–59) and the old (aged 60+). The sample size is 18 253, with 12 888 young and 5365 old individuals of all kinds of occupational status, including non-working housewives. Income data are on an individual basis, with net income calculated as gross income plus social security benefits minus premiums. Gross income

[5] This incompleteness could be caused by an insufficient sample size rather than institutional factors. My sample size, however, seems to be large enough to neglect this possibility and the data are randomly selected.