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Social Welfare Financing Solutions for Improving Intergenerational Equity in Linear Programming Simulation Model for National Health Insurance

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Chapter 1

Introduction

1 Introduction

This study is entitled 'Social Welfare Financing Solutions for Improving Intergenerational Equity in Linear Programming Simulation Model for National Health Insurance.' For starters, I'd like to discuss why this topic needs to be discussed. It is largely related to what causes the issue of equity between generations.

Intergenerational inequity in social security arise when the net contribution arrived at by subtracting the amount of benefits received from the social welfare spending paid for the entire life span by birth cohort (defined as generation hereinafter) differs from generation to generation in terms of plus or minus sign and size of amount. Specifically, if the net value of a given generation throughout the entire cycle of life appears positive, it can be said that this particular generation has been only on the giving side. The higher the number, the larger the degree of contribution. On the other hand, negative numbers represent those on the receiving end. The smaller the number, the larger the degree of benefits.

Such discrepancy in financial burden and benefits between generations indicates discrimination in terms of rights and obligations. This, in turn, hinders each generation from enjoying equal opportunities and presents an issue from the perspective of justice underpinned by equal opportunity. Additionally, those at a disadvantage may end up developing views that are skeptical of social welfare programs. If the cross-generational inequity becomes serious, the number of people with negative views would increase and the opposition may intensify, too. In a democratic society where the legitimacy of a policy shall be decided by the majority, this could possibly endanger the existence of the social welfare system itself. In that regard, the intergenerational equity problem triggered by the unbalanced burden and benefits of the welfare system is a social issue that we can't afford to overlook, and it is essential to have it addressed.[1)]

Funding social welfare presents a financial burden and constitutes part of the intergenerational equity problem on both burden and benefit sides. Eventually, the issue of financing disparity should be handled as part of the cross-generational equity problem in which both burden and benefit are taken into consideration.

Against this backdrop, this study is designed to examine intergenerational equity in terms of social welfare and lay out funding solutions to achieve such an aim, thereby ensuring cross-generational equity in social welfare and financing. Although what is theoretically handled to this end falls under

1) Please see Gun-Chun Ryu, et al. (2004, 152).

the entire coverage of the social security scheme, this study has been limited to national healthcare as the outcome of simulation actually covers a similar scope.

Section 2 looks into the existing studies to provide a theoretical background for the study and specify the agenda thereof. Section 3 describes a linear programing-based equity model and relevant data for national health insurance, whereas Section 4 reviews the results of analysis conducted by utilizing the model and data mentioned in the preceding section. Finally, Section 5 discusses the conclusion and political implications for better equity between generations.

Chapter 2
Existing Studies, Theoretical Background, and Study Topic

1. Generation
2. Metrics for Intergenerational Equity
3. Theoretical Background for Identifying Study Topic
4. Study Agenda

2 Existing Studies, Theoretical Background, and study Topic

1. Generation

In order to specify the agenda of this study under the theme of intergenerational equity in terms of social welfare financing, the concept of generation should be clarified first.

Generation basically refers to a group of people occupying the same position over time. The length of time shared by generation varies depending on the types of events that tie them together. In this study, a collection of those sharing the one-off event as being born at the same time will be called 'generation'. In a word, birth cohort is defined as generation (Shryock, Siegel and Associates, 1976, 550).

2. Metrics for Intergenerational Equity

Next, the concept of cross-generational equity in social welfare should be embodied. This is closely related to the measuring of intergenerational equity in social security. It can be dealt with from multiple angles, but the most sensitive issue lies in how much money each generation ends up paying and receiving. For equity, you may be misled to focus on financing only, but this could increase the likelihood of error in the assessment of equity. Therefore, it is critical to look at usage side, too (Musgrave and Musgrave,1980, 509; Fleurbaey and Schokkaert, 2012, 1068-1069). In other words, even if this study is carried out with the title of intergenerational equity problem in terms of social welfare financing, both funding and utilization should be examined together to measure equity, and based on that, measures should be devised to improve equity by assessing how the funding affects such two-sided equity.

In this study, expected net contribution will be employed to gauge cross-generational equity as it represents the present value arrived at by applying the discount rate relative to a particular time (either year of birth or a specific time for comparison) to the net contribution obtained by deducting the amount of benefits received from the amount paid over the entire life cycle since a person typically born in time (t) has joined social welfare system (Kleindorfer and Schulenburg, 1986, 117-118).

3. Theoretical Background for Identifying Study Topic

This study originates from the question as to what should be done specifically if an obligation for future generation exists, on the premise that the existence of such an obligation and its grounds are provided[2]. This is believed to be directly related to

2) Please see Geun-Chun Yu, et al. (2013, 19-37).

the content of equity. As such, it could be more meaningful and productive if this issue is handled with specific examples rather than being generally discussed. Below, we will look into inter-generational equity in social welfare in more detail.

(1) Type of Social Welfare Financing

The study attempts to identify any issues regarding cross-generational equity in social welfare and resolve them, if any, by putting a balanced welfare system in place. To this end, we will define the type of social welfare funding as a political tool.

In this study, social welfare financing is classified into premium, taxes (i.e. special-purpose tax, general tax) and personal contribution. As it offers social security, self-contribution finances the private portion.

(2) A Political Means for Enhancing Equity

Net contribution, a measure of equity, is expressed as stated below from both the individual and social welfare operator perspectives:

Net contribution = contribution - benefits (From individual's viewpoint) = income - expenses (From social welfare operator's viewpoint)

As discussed above, the key components of equity are contribution (income) and benefits (expenses). Since what impacts them eventually affects the (+/-) sign and size of net contribution, it can be used as an effective policy tool to enhance equity.

The financing considerations for better equity reviewed in this study include premiums for social insurance, taxes, personal contribution for social welfare, fiscal balance for social security, and reserve accumulated. (Under the regime of pure pay-as-you-go, the fiscal balance excluding contingency reserve is 0, but in reality a mix of pure pay-as-you-go and fully-funded mode is implemented, thus allowing fiscal balance to yield a surplus and some reserving to occur.)

(3) Details of Intergenerational Equity and Mathematical Formulas[3)]

Detailed content of cross-generational equity involves what obligations are specifically entailed if the problem of equity arises, which in turn constitutes the content of equity we've aimed for. As each specific issue may have different features, it could be difficult to discuss it in general terms.

3) This concerns social welfare function in economics. Social welfare function indicates the level of satisfaction of a society by defining the level of satisfaction of each individual member of a society as an independent variable (Jun-Gu Lee, 1989a, 641-647).

In consideration of the content of equity that can be embraced as policy goals in social welfare, I think that it is crucial to know as much content as possible that can serve as the objectives of equity. The following illustrates what can be considered goals of this study:

First, any discrepancy in the size and degree of net contribution from generation to generation points to inequity. As such, we can set a goal to ensure for all generations to have equal contribution and benefit, thus bringing net contribution down to 0, similar to the reserve-financed method employed by private insurers.

Second, equity may bear some relevance to those with least advantage. The concept of equity is hard to set in if there exist any generations deemed disproportionately disadvantaged, no matter how fair it appears in terms of give-and-take between generations. That said, considerations for the weak can be perceived as one of objectives for equity.

Third, if net contribution stays positive, the larger the number, the more you stand to lose. In contrast, smaller numbers in negative territory work in your favor. Subsequently, we can aim for moving toward smaller net contributions for all generations if possible.

Fourth, the current social welfare system places its top priority on financial sustainability. If other equity-related objectives are met and yet we still keep encountering financial sustainability problems, it could be meaningless. With that said, financial sustainability can be a good candidate for objective consideration, along with equity.

Fifth, proper goals for equity can be established by assigning appropriate weight to the aforementioned objectives and the components thereof.

The content of equity to be used for this study is configured based on the goals discussed above. It mainly comprises 'minimizing inequity (MI)' for reducing the total size of net contribution, 'minimizing maximum inequity (MMI)' for mitigating the conditions of the least benefitted generation according to Rawls principles (with the largest net contribution E(t)), and 'minimizing net-transfer (MN)' to minimize the sum of net contributions. The detailed information is stated below[4]:

a. Minimizing Inequity (MI)

MI minimizes the total size of inequity. Equity is achieved when net contribution E(t) equals to 0. In other words, the amount contributed is offset by the amount received over the cycle of life. It works similar to the calculation of premium against risk. From this standpoint, minus or plus E(t) means inequity. Mathematically, it involves minimizing the sum of absolute values of each generation's E(t) for a given period.

4) Please see Gun-Chun Ryu, et al. (2004, 153-154) for more detailed information on MI and MMI.

$$Min \sum |E(t)|$$

This keeps E(t) value from varying sharply while pushing net contribution closer to 0 by equally treating net contribution or benefit. As the embodiment of the first objective mentioned earlier with regard to equity, it also considers financial sustainability as it works toward matching the income of social welfare operators against their expenses.

b. Minimizing Maximum Inequity (MMI)

MMI emphasizes the protection of the weakest.[5] As part of equity, it values improving the conditions of the most disadvantaged in terms of intergenerational equity. The MI equally treats net contributor or recipient, which "results in minimizing the deviation of net contribution around 0, yet possibly allows for putting some generations at an extreme disadvantage. On the contrary, MMI doesn't treat them equally. Instead, it focuses on enhancing the situation of the weakest who shoulder the largest burden"(Geun-Chun, Yu & Others 2004, 154). Eventually, it allows net contribution to be more equally

5) "This represents the theory of justice by Rawls (1971) (Jun-Gu Lee, 1989b, 62). Rawls introduced two justice principles expected to be selected in the original position: liberty principle and difference principle. The principle of difference fairs well in the midst of some inequity rather than in complete equality, if such inequity works in favor of all members of a society, especially those with the least advantage (Schulenburg, 1987, 165; Jun-Gu Lee, 1989b, 60-62)" (Gun-Chun Ryu & Others, 2004, 153).

divided. In mathematical terms, MMI concerns minimizing social welfare function under the theory of Rawls characterized by the maximum inequity of the weakest (maximum E(t)).

$$Min\ \ Max\ \ E(t)$$

This relates to the second objective discussed earlier with financial sustainability not taken into consideration.

c. Minimizing Net-transfer (MN)

MN embodies the third objective of equity mentioned earlier, that is, the smaller the net contribution, the better for each individual generation. When it is extended to the entire generation, it suggests minimizing the sum of net contributions, which is also known as a social welfare function under the theory of utilitarianism. It can be expressed as follows:

$$Min\ \sum E(t)$$

This aims to keep net contribution at minimal possible level by differentiating the handling of net benefit (-) and net contribution (+). Reducing net contribution for all generations means falling income and rising expense for social welfare operator. In that regard, MN contains a risk of not considering financial sustainability.

The equity-related objectives discussed above are based on value judgment, thus carrying no absolute supremacy. Also, we can't say that it includes all possible objectives with regard to equity. Depending on goals, there may be other relevant contents. However, as this study contains what was mainly discussed in the previous studies including social welfare function under the theory of both utilitarianism and Rawls while touching upon financial sustainability especially stressed in the area of social welfare, I believe that it is practically sufficient enough in terms of content.

4. Study Agenda

Based on what was defined earlier, the study topic can be specified as follows:

This study is aimed at seeking ways to improve equity between generations in terms of social welfare financing. In the studies usually dealing with financing equity, the below two questions are most frequently asked: (See Morris, 1998, 90)

1) Do the well-off share more burden for financing than the less well-off?

2) Are all members of our society properly protected against unplanned expenses incurred by any unexpected social welfare-related risks?

I think that it is helpful to configure the study topic by taking these two questions into account when addressing the problem of intergenerational inequity in social welfare funding. This study deals with the first question in which the second question is also handled. The second question is a matter of protection. In the context of the cross-generational issue, it fails to sustain the social welfare system, leaving some generations without social security benefits or putting others at an extreme disadvantage. I believe that the issue of system sustainability is being handled with the zero sum principle[6)] derived from inter-temporal budget constraints in generational accounting, while considerations for the least benefitted generation are being addressed by MMI.

For starters, the components of intergenerational status quo comprising the well-off and the least well-off can be categorized by net contribution E(t) which is considered a barometer of cross-generational equity. Larger E(t) means being at a disadvantage, and the weakest members of a society belong to this group. Smaller E(t), on the other hand, puts you at an advantage, and the strong fall into this category. Consequently, special attention should be paid to those generations deemed the most and least benefiting from a particular welfare system when assessing equity in social welfare financing. Having said that, the question for study topic can be rephrased as follows:

6) Please see Gun-Chun Ryu & Others (2013, 89-90).

Do generations having the upper hand in intergenerational equity take on more financial burden than those that don't? If not, what actions should be taken to remedy this problem?

However, this topic can't be directly addressed due to the unique nature of cross-generational equity different from the previous studies. It faces two hurdles: First, the existing studies utilized the portion of social welfare in total income for each income bracket to measure equity. To gauge intergenerational equity, the social welfare spending shared by each generation against generation-based income should be considered, but such data is currently not available and the creation thereof is also unlikely. Second, the previous studies employed income to determine the weak and strong, but in this study, net contribution, a measure of equity, takes its place and makes a new yardstick. Also, it incorporates burden into our study target, along with benefits. So, any variance in burden for enhanced equity may change the index of equity itself, altering the weak and strong, thereby causing the existing equity improvements originally applied for the weak and strong to become meaningless.

In light of these two challenges, an approach different from the existing studies should be taken to address our study topic. The first challenge can be resolved by giving up the measuring of equity limited to burden and moving toward embracing net contribution with not only burden but also benefit included to assess equity. This approach has its own merits and demerits. One weakness lies in failing to focus on burden. But, it can draw a more realistic outcome as it goes so far as to consider benefits more precisely. As such strength outweighs the weakness, it is believed this approach presents no risk. The second challenge is addressed by the first solution. To gauge equity in social welfare financing, the intergenerational equity itself is put to use. This means that in order to determine burden according to equity in funding, cross-generational equity should be defined first. Then, proper burden should be assigned accordingly. Finally, measures should be sought to meet such burden, which also can serve as a solution for enhancing equity in social welfare financing.

The position of the weak and strong will be first identified based on the content of equity set forth in cross-generational equity. Then, proper burden corresponding to the status of equity between generations will be defined and relevant solutions will be recommended. The unique characteristics of intergenerational equity in financing can be considered independently here. Consequently, corrective actions for improved equity in social welfare funding will not alter the content of equity itself. In light of this consideration, the study topic can be rephrased as follows:

What is the status of cross-generational equity allowed by the social security scheme? What is the content of burden? What policies can be implemented to meet such a burden?

We've discussed intergenerational equity and social welfare financing tools specifically so far. In the following section, We will talk about the programming model adopted in national health insurance in an effort to answer the questions raised above.

Chapter 3
Linear Simulation Model and Data in National Health Insurance

1. Simplifying Assumption
2. National Health Insurance
3. Data Used for Simulation Model Calculation

3 Linear Simulation Model and Data in National Health Insurance

As mentioned in the preceding Section 2, directly seeking equity improvements in social welfare financing is limited due to the nature of cross-generational equity. As such, we should work around capturing the values of financing-related variables (i.e. premium, taxes, self contribution) before devising appropriate funding policies. To this end, it is essential to build a linear programming model that enables intergenerational equity to be achieved[7]. The content of equity consists of MI, MMI, and MN, as seen in the previous Section 2.

As specified below, simplifying assumptions is required to build linear simulation model allowing for intergenerational equity.

1. Simplifying Assumption

Simplifying assumptions is conducted as follows:

1) Concurrent birth cohort (= the same generation) is grouped into units of 10 years, which doesn't hinder the purpose of our study mainly focusing on the direction of change

7) Please see Seok-Cheol Yun (1987) and Murty (1976) for more information on linear simulation model.

and effect. Also, it can help reduce the number of calculations during actual simulation.

2) Maximum life expectancy (D) is set at 100 years old. The basic assumption here is that you are born in year 0 and die when you turn 100. In other words, you live from 0 to 99 years old.

3) The outcome of simulation is reckoned from the planning period in which the relevant policy is implemented and takes effect. Here, we randomly assume the start of such a period in the 2020s, which is in the near future and easy to calculate (2020-2029). In this case, the policy planning period ends in the 2120s (2120-2129) when the generation born at the onset of the policy will pass away. If we assign numbers in unit of 10 years, the planning period ranges from 11th to 21th period (t=[11, 21]).[8] Since the effect of equity policy needs to be analyzed throughout the entire life cycle of all people living in such period by net contribution, the generation allowing the calculation of net contribution begins in the 1920s (t=1) and ends in the

8) For reference, 10-year unit period and corresponding actual period are described as follows: t=1 1920-29, t=2 1930-39, t=3 1940-49, t=4 1950-59, t=5 1960-69, t=6 1970-79, t=7 1980-89, t=8 1990-99, t=9 2000-09, t=10 2010-19, t=11 2020-29, t=12 2030-39, t=13 2040-49, t=14 2050-59, t=15 2060-69, t=16 2070-79, t=17 2080-89, t=18 2090-99, t=19 2100-09, t=20 2110-19, t=21 2120-29, t=22 2130-39, t=23 2140-49, t=24 2150-59, t=25 2160-69, t=26 2170-79, t=27 2180-89, t=28 2190-99, t=29 2200-09, t=30 2210-19, t=31 2220-29

2120s (t=21)[9]. As such, the age-based information required here is the data from 1920s to 2220s.

4) Making several assumptions for the pre-planning period is also required (t 〈 11), as they serve as a baseline for comparison.

- Social insurance: Pay-as-you-go mode, Fiscal balance F(t)=0
- Tax: Balanced budget, Fiscal balance F(t)=0
- Self contribution: N/A (health insurance, long-term care). Despite actual payment of contribution, it was excluded in our data used here, so the personal contribution is considered 'Not occurred'.
- Private transfer: It is considered only when obtaining the total value for the entire welfare system.

5) Introduce into the 'planning period' t=[11, 21] a policy variable that affects the net contribution. This variable also impacts contribution (income) and benefits (expenses).

- Reserve allowed: Fiscal balance F(t)〉=0
- Factors affecting contribution: To be excluded from benefits. They include self-contribution for health insurance and

9) The start of the period, 2020s (2020-2029, t=11), includes people born in the 1920s, specifically from 1920 to 1929 who turn 100 years old (1920-1929, t=1). So, calculating E(t) requires dating back to this cohort. Likewise, those born at the close of the period (2120s; 2120-2129, t=21) turn 100 in the 2220s (2220-2229, t=31). So, this future cohort should also be considered when estimating E(t).

long-term care insurance, which falls within the range of $0 \leq \alpha \leq 1$ while being divided into fixed and variable. Meanwhile, a hike in pension premium is possible but due to the complexity propelled by the consideration of income replacement rate, it will be forgone here. In theory, however, it can be reflected.

- Factors affecting benefits: As for pension, a fall in income replacement rate will be factored in. We can consider raising protection for health insurance, but this won't be handled here due to the complexity, as well.

6) Life cycle: Make an assumption to live up to 100 years old. Age will be tied together as specified below, since it is essential to coordinate with the grouping of generation by 10 years.

- Age variable τ: 0(0-9), 1(10-19), ..., 9(90-99)
- That is, $0 \leq \tau \leq 9$, [0, 9]

7) Categorize male and female to reflect a gap between men and women (i.e. medical expenses)

- Male j=1, Female j=2

8) Add income class to reflect any change in the size of premium or benefit based on income bracket.

Quintile income class	1/5	2/5-4/5	5/5
i (representing group)	1	2	3
μ(i) value	20%	60%	20%

9) The following assumptions will be made between age and amount of contribution:

- Health insurance

0-19 τ〈2 : No contribution is made given the position as a dependent.

20-59 2≤τ〈6: Contribution will be paid as per income as they are part of working population.

60- 6≤τ≤9: 50% of the contribution of those in working age should be paid as it is desirable for retirees to pay their share to allow public pension to take hold.

10) Objective function: This model consists of objective function and constraint. As constraint varies from system to system, it will be handled independently for each system. However, objective function will be defined here as it is commonly shared.

- 3 equity concepts: minimizing inequity (MI), minimizing maximum inequity (MMI), minimizing net-transfer (MN)
- Decision variable: In the case of average contribution or tax of B(t), self contribution of α(t) and increasing benefit of β(t), 1≤β≤5 means an increase of up to 5 times whereas 0≤β≤1 represents a decrease.

- E(t) calculation cohort t=[1, 21]: Include generations who stay alive during the 'planning period.'
- Three objective functions are calculated as described below, which is equivalent to implementing three equity-boosting policies:

1. Minimizing Inequity (MI)

$$\underset{\{B(t),\alpha(t),\beta(t)\}}{Min} \quad \sum_{t=1}^{21}|E(t)|$$

2. Minimizing Maximum Inequity (MMI)

$$\underset{\{B(t),\alpha(t),\beta(t)\}}{Min} \quad Max\ E(t), \quad t\in[1,\ 21]$$

3. Minimizing Net-transfer, (MN)

$$\underset{\{B(t),\alpha(t),\beta(t)\}}{Min} \quad \sum_{t=1}^{21}E(t)$$

11) With regard to constraints, national health insurance, public pension, and national basic livelihood security scheme will be separately discussed.

2. National Health Insurance

The simulation model will be configured as follows:

1) Financing method F(t)

- Calculate for each age group relative to period t. In case of period t and age τ, period (t-τ), that is, (t-τ) cohort should be formed and age τ data from (t-τ) cohort should be used. At time of calculation of F(t), average medical expenses r((t-τ), τ, j) mean cohort, age, and sex, respectively.

- Average contribution y(t, τ, i): To be adjusted based on age τ and income i.

a. Age τ〈2 :	regardless of i (i=1,2,3) y=0 (dependent)
b. 2≤τ〈6:	i=1 low income bracket y=0.5
(Working age)	i=2 middle income bracket 1
	i=3 high income bracket 1.5
c. τ≥6	i=1 low income bracket y=0.25
(Retired)	i=2 middle income bracket 0.5
	i=3 high income bracket 0.75

- Two-fold financing method

a. Pay-as-you-go: Reserving not allowed

$$F(t) = F(t-1) + \sum_{\tau=0}^{9}\sum_{j=0}^{2}\sum_{i=0}^{3} \times [y(t-\tau,\tau,i)B(t) - (1-\alpha(t)\, r(t-\tau,\tau,j)]\, n(t-\tau,\tau,j)\, \mu(i) = 0$$

; provided, however, that t equals to [1,31] (t=[1,31]). Also, the reserve additionally set at the second section can't exceed the amount of benefit for the same period. (Without this condition, the outcome of calculation will become unreasonable.)

b. Reserving is allowed for the 'planning period.'

F(t)〉=0 t=[11, 21]

F(t)=0, t〈11, t〉21

2) Net contribution E(t)

- Calculate for each age group relative to cohort t. Apply t to the year of birth. In the case of cohort t and age τ, the year becomes (t+τ). So, for the period-related variables such as B(t) and α(t), t is replaced by (t+τ) to become B(t+τ) and α(t+τ). This indicates that for the same year, identical premium and self-contribution are used for variables.

- As E(t) refers to average contribution by a single person representing a given cohort (to compare against other cohorts with different population), please multiply it by $[n(t,1,j=1,2)]^{-1}$before dividing by the number of population (the sum of men and women) who were born in period t and stay alive until 19 years old.
- Discount rate z(t+τ): In order to convert the net contribution of generation t for the relevant period of t+τ into the present value of the year of birth t, the formula $z(t+\tau)=\frac{1}{(1+\rho)^{t+\tau}}$ (ρ is discount rate) is applied. If a different base year of t' is used, you should first check if the year of birth t is bigger or smaller than t'. If it is smaller, $z(t+\tau)=\frac{1}{(1+\rho)^{t'-(t+\tau)}}$ is utilized. If found bigger, the formula $z(t+\tau)=\frac{1}{(1+\rho)^{(t+\tau)-t'}}$ is employed.
- y(t, τ, i): identical to the above
- r(t, τ, j): age 'τ'-th field of generation 't'-th line of benefits data, j represents male/female.
- n(t, τ, j): age 'τ'-th field of generation 't'-th line of population data

- j represents male/female - μ(i): identical to the above
- E(t) calculation formula

$$E(t) = (n(t,1,j=1,2))^{-1}\sum_{\tau=0}^{9}\sum_{j=1}^{2}\sum_{i=1}^{3} z(t+\tau)\,[y(t,\tau,i)\,B(t+\tau) \\ -(1-\alpha(t+\tau))\,r(t,\tau,j)]\,n(t,\tau,j)\,\mu(i)$$

Subject to t ∈ [1,31], The above formula can be changed as follows:

$$E(t) = (n(t,1,j=1,2))^{-1}\{\ \sum_{\tau=0}^{9}\sum_{j=1}^{2}\sum_{i=1}^{3} z(t+\tau)\,y(t,\tau,i)\mu(i)n(t,\tau,j)\ B(t+\tau) \\ -\sum_{\tau=0}^{9}\sum_{j=1}^{2} z(t+\tau)(1-\alpha(t+\tau))\,r(t,\tau,j)n(t,\tau,j)\}$$

3) Cost sharing conditions α(t)

- 0≤α≤1
- α(t)=0, t〈11, t〉21,
- 0≤α≤1, t=[11, 21], 'policy planning period'

4) Health insurance simulation model and calculation

a. Simulation model 1

- Age-based cost structure over the entire period is identical to the 2010s when t equals to 10 (Detailed information is available in table form later). The change in age structure will be affected only.
- Discount rate for the entire period: 0
- b. Simulation model 2
- Varying medical expenses subject to certain conditions: Reflect medical expenses growth of Korea by 10-year period (Detailed data available in a table form)

- $t < 6$: 10%, $t=6$: 100% (Introduction of national health insurance plan), $7 \leq t < 11$: 400% (Expansion period, increasing protection, etc.), $11 \leq t \leq 31$: 50% (Cost savings effect since the beginning of 'planning period')
- 10-year discount rate: $t < 6$: 0.2 (annually 1.8%), $6 \leq t \leq 31$: 0.5 (annually 4.1%)

c. Simulation model 3

- Rising medical expenses: Identical to Model 2
- Only 10-year discount rate growth has expanded: $t < 6$: 0.4 (annually 3.4%), $6 \leq t \leq 31$: 0.7 (annually 5.4%)

d. Type of calculation

- 1. Each simulation model 1, 2, 3 are subject to $F(t)=0$ and $F(t) \geq 0$. This is to figure out what impact the reserve has on cross-generational equity.
- 2. Calculate status quo at simulation 1, 2, and 3. In cases where $B(t)$ and $\alpha(t)$ are determined by $F(t)=0$ with no involvement of equity (Calculation isn't allowed if $F(t) \geq 0$)
- 3. To compare against status quo at each simulation 1, 2, 3, calculate 3 equity concepts in the case of fixed and variable self contribution. ($\alpha(t)$: fixed, b. $\alpha(t)$: variable)

3. Data Used for Simulation Model Calculation

(1) Population data will be subject to the following assumptions:

- n(cohort period t, age τ, male/female j): Reflect aging and stationary population trends.
- KOSIS age data for 1960-2060 compiled by the National Statistics Office
- Each 10-year period is represented by 9th age structure thereof. Examples include t=5 of 1960s and t=13 of 2040s. Define each age band as the sum of relevant age groups. If the number of population at the bottom failed to be segmented by age group as required by our study, it should be broken down properly with historical population trends taken into consideration. The population structure of the 1960s should be used for the 1950s.
- Before vs after stationary population: Let's assume that the mortality rate didn't change for a certain period of time in the past while a certain number of births are observed starting from the 2050s. (Applicable to both men and women born in the 2050s up until the year 2220 (t=14~t=31))
- Birth cohort t in population data: t here may refer to birth cohort or a particular period. The age structure of a particular period t is age τ of t-τ period cohort if the age

is τ (ascending one by one into the upper right). Specifically, it represents age τ field of t-τ period cohort which dates as far back as the number of age groups (that is, the number of people who belong to the specific age group subject to period t and age τ).

- For the areas left blank preceding the number of people survived in the 2050s, have them filled with the growth rate of the last field by presuming it as survival rate.
- Please see Gun-Chun Ryu, et al. (2004) in the case of $t \leq 4$.

(2) Personal benefits data (=Expense related data of social welfare operator)

- $r(t, \tau, j)$
- Set as default the identical age and cost structure of the 2010s
- Change cost structure based on appropriate assumptions. Assuming no change in cost structure is also allowed.

Chapter 4
Analysis Results of Equity Improvements Simulation

1. Analysis Methodology
2. Analysis on Health Insurance Results

4 Analysis Results of Equity Improvements Simulation

1. Analysis Methodology

(1) Analysis Results Declaration Method and Significance

Since there are many tables existing for analysis, it is necessary to define how to present the analysis outcome. The analysis method can be formalized depending on the type of analysis table used. All tables are labeled as (head numeric)-(tail numeric) as in 1-1, 1-2, etc.

Head numbers concern the three simulation models described in the previous section regarding the type of simulation model calculation. The following meanings are shared across all tables:

- Head no. 1: Benefit structure data of 2010 is available for all years and generations with a discount rate of 0.
- Head no. 2: There is a rise or fall in benefit with the discount rate larger than 0. All changes occur within the 'planning period.'
- Head no. 3: The same benefit data as in model 2 is used, yet with larger discount rate.

Tail numbers represent the following:

- Tail no. 1: Reserving isn't allowed. F(t)=0
- Tail no. 2: Reserving is allowed. F(t)≥0

For example, 1-1 contains the benefit information of 2010s with a discount rate of 0. Reserving isn't allowed in this financing model.

(Head no.)-(Tail no.) is followed by the symbols Obj 1, Obj 2, Obj 3, and status quo, indicative of the detailed policies for enhanced equity. Each symbol is defined as follows:

- Obj 1: Objective function MI (minimizing inequity) is applied.
- Obj 2:Objective function MMI (minimizing maximum inequity) is applied.
- Obj 3: Objective function MN (minimizing net-transfer) is applied.
- Status quo: B(t) and E(t) subject to F(t)=0 are employed without objective function applied. In relation to self contribution or benefit, constant 0 or 1 is used. Unsurprisingly, it is handled only in the case of 1-1, 2-1, and 3-1.

Next, con and var are defined as stated below:

- con: If the analysis of self-contribution or benefit yields a constant
- var: If the analysis of self-contribution or benefit yields a variable

For instance, 1-1 Obj 1 con involves applying objective function MI to the simulation model with the same benefit structure as in 2010 while assigning a constant for self-contribution or benefit.

(2) Analysis Method for Results Table

For the analysis of the results table, we can establish a formalized process in terms of sequence, type of target tables, and content of analysis. The underlying principle here is to allow one change at a time to draw an implication in change as in the case of comparative statics, thereby analyzing a pair of tables in which such change is observed.

The purpose of analysis for the return values table is to identify if any change in decision variables such as premium, tax B(t), self contribution or benefit (α or β), and reserve-based F(t) has made some contribution to the altering of intergenerational equity. Now, we will discuss further the type of results table, analysis method, and content.

A) Analysis from Model 1

(A) 1-1 status quo table analysis

- In circumstances where your own contribution stands at 0 (or with income replacement rate or current benefits unchanged) amid no change in costs or benefits, analyze the varying B(t) and E(t) which reflect the change of population and sex only.

- As the population data used for this study incorporates aging, aging related interpretation is particularly required.

(B) 1-1 Obj 1, Obj 2 and Obj 3 compared against 1-1 status quo

- Link varying premium/tax and self contribution/benefit to the purpose of each objective function. Verify if the purpose of each objective function is met.
- Run a comparison between con and var for each objective function.

(C) 1-1 vs 1-2 comparison by Obj

- Check if the reserve-enabled policy (F(t)≥0) for each Obj has reinforced the purpose of relevant objective function with regard to equity.
- Run a comparison between con and var for each objective function.

B) Analysis from Model 2

Simulation model 2 mainly focuses on analyzing what relevance the varying benefit and the rising discount rate have on E(t) in relation to intergenerational equity.

(A) 1-1 vs 2-1 status quo comparison

- Examine how the above two changes affected B(t) and E(t).

(B) 2-1 Obj 1, Obj 2, and Obj 3 compared against 2-1 status quo

- Link varying premium/tax and self contribution/benefit to the purpose of each objective function. Verify if the purpose of each objective function is met.

- Run a comparison between con and var for each objective function.

(C) 2-1 vs 2-2 comparison by Obj

- Check if the reserve-enabled policy ($F(t) \geq 0$) for each Obj has reinforced the purpose of relevant objective function with regard to equity.
- Run a comparison between con and var for each objective function.

C) Analysis from Model 3

Since the difference between Model 2 and 3 is an increase in discount rate only, analyze what implications it has caused.

(A) 2-1 vs 3-1 status quo comparison

- Examine how the surging discount rate affected B(t) and E(t).

(B) 3-1 Obj 1, Obj 2, and Obj 3 compared against 3-1 status quo

- Link varying premium/tax and self contribution/benefit to the purpose of each objective function. Verify if the purpose of each objective function is met.
- Run a comparison between con and var for each objective function.

(C) 3-1 vs 3-2 comparison by Obj

- Check if the reserve-enabled policy ($F(t) \geq 0$) for each Obj has reinforced the purpose of the relevant objective function with regard to equity.

- Run a comparison between con and var for each objective function.

2. Analysis on Health Insurance Results[10)]

(1) Analysis from Model 1

A) 1-1 status quo table analysis

In case of no change in cost and benefits with self-contribution A(t) standing at 0, the premium B(t) reflecting the change of population and sex only is continuously on the rise. This is consistent with our findings that amid the lowering birth rate and aging population, the premium for the future generation is bound to surge, putting them at a disadvantage. Premium will be converged toward a certain value (about 1,432,000 won) when the effect of stationary population (after t=14) finally takes hold. (t=23 and onwards)

Net contribution E(t) yields negative numbers for all generations during the 'planning period (t=11-21)'. This can be attributed to the disproportionately unbalanced structure of benefits over burden rather than the negative effect of aging. According to zero sum theory, this could trigger financial sus-

10) The calculation of the linear simulation model was conducted by Dr. Kyung-Min Kim who is on Ph. D. program at the Industrial Engineering Dept. of Seoul National University by employing a commercial optimization program, CPLEX OPL 12.5.

tainability issues, thus calling for an overhaul. This also agrees with Chapter 4 'Analysis Results on Current Status and Future.' Minus numbers are getting smaller before growing bigger, which occurs in the process of converging toward stationary population. Nevertheless, it is believed that the analysis out-come appears relatively unfavorable for future generations.

〈Table 1〉 Health insurance simulation model 1-1: status quo

Model 1-1: status quo				
t	B(t)	E(t)	A(t)	F(t)
11	544.701	-723.514	0.000	0.000
12	637.638	-1,179.446	0.000	0.000
13	697.020	-1,793.561	0.000	0.000
14	740.151	-2,323.280	0.000	0.000
15	790.690	-1,808.951	0.000	0.000
16	851.786	-1,387.540	0.000	0.000
17	909.988	-989.573	0.000	0.000
18	976.339	-652.465	0.000	0.000
19	1,048.126	-322.483	0.000	0.000
20	1,127.310	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000

B) 1-1 Obj 1, Obj 2 and Obj 3 compared against 1-1 status quo

a. Obj 1

- In the case of con, it returns the same B(t) and E(t) results as status quo, suggesting that adjustment isn't allowed if self contribution is identical.
- With regard to var, if t=11 and 12, the self contribution α equals to 1 and premium becomes 0. As this is tantamount to the termination of insurance policy, it is in reality hard to be put into practice. Yet, this helps bring E(t)s closer to 0

from equity perspective. For instance, the objective function con marked 11,273, which was reduced to 10,840 as for var.

〈Table 2〉 Health insurance simulation model 1-1: Obj 1 con results

Model 1-1: Obj 1 sum |E(t)|, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	544.701	-723.514	0.000	0.000
12	637.638	-1,179.446	0.000	0.000
13	697.020	-1,793.561	0.000	0.000
14	740.151	-2,323.280	0.000	0.000
15	790.690	-1,808.951	0.000	0.000
16	851.786	-1,387.540	0.000	0.000
17	909.988	-989.573	0.000	0.000
18	976.339	-652.465	0.000	0.000
19	1,048.126	-322.483	0.000	0.000
20	1,127.310	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
sum |E(t)|		11,273		

〈Table 3〉 Health insurance simulation model 1-1: Obj 1 var results

Model 1-1: Obj 1 sum |E(t)|, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	0.000	-458.898	1.000	0.000
12	0.000	-1,010.641	1.000	0.000
13	697.020	-1,793.561	0.000	0.000
14	740.151	-2,323.280	0.000	0.000
15	790.690	-1,808.951	0.000	0.000
16	851.786	-1,387.540	0.000	0.000
17	909.988	-989.573	0.000	0.000
18	976.339	-652.465	0.000	0.000
19	1,048.126	-322.483	0.000	0.000
20	1,127.310	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
sum |E(t)|		10,840		

b. Obj 2

- In the case of con, it returns the same B(t) and E(t) results as status quo. E(t) equally marks 0 if t=21 (the weakest). This indicates that adjustment isn't allowed if self contribution is identical.
- With regard to var, if generation t=14-16, self contribution α equals to 1 and premium becomes 0. As this is tantamount to the termination of insurance policy, it is in reality difficult to be put into practice. Though such change doesn't alter E(t) equaling to 0 for the weakest (t=21), the net contribution E(t) however diminished for t=11-14 generation, making some progress. E(t) suffered a setback amid the expanding net contribution with t=15-16 generation. Obj 2 MMI shows a tendency of improving the overall picture, as the positive implications of the enhanced stance of the weakest for E(t)s of other generations outweigh their negative implications.

〈Table 4〉 Health insurance simulation model 1-1: Obj 2 con results

Model 1-1: Obj 2 Emax, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	544.701	-723.514	0.000	0.000
12	637.638	-1,179.446	0.000	0.000
13	697.020	-1,793.561	0.000	0.000
14	740.151	-2,323.280	0.000	0.000
15	790.690	-1,808.951	0.000	0.000
16	851.786	-1,387.540	0.000	0.000
17	909.988	-989.573	0.000	0.000
18	976.339	-652.465	0.000	0.000
19	1,048.126	-322.483	0.000	0.000
20	1,127.310	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
Emax		0		

〈Table 5〉 Health insurance simulation model 1-1: Obj 2 var results

Model 1-1: Obj 2 Emax, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	544.701	-2,102.862	0.000	0.000
12	637.638	-3,141.180	0.000	0.000
13	697.020	-3,245.498	0.000	0.000
14	0.000	-2,715.506	1.000	0.000
15	0.000	-1,555.487	1.000	0.000
16	0.000	-1,218.736	1.000	0.000
17	909.988	-989.573	0.000	0.000
18	976.339	-652.465	0.000	0.000
19	1,048.126	-322.483	0.000	0.000
20	1,127.310	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
Emax		0		

c. Obj 3

- In the case of con, if generation t=11-21 throughout the entire 'planning period,' the self contribution α equals to 1 with premium hitting 0. Since this is tantamount to full termination of insurance policy for the same period, it is in reality difficult to put into practice. However, this has resulted in enhancing equity as intended by the objective function of MN by driving net contribution toward smaller numbers with the objective function arriving at −23418.

- With regard to var, if generation t=13-21, self contribution α becomes 1 and premium 0. Since this is tantamount to the termination of insurance policy, it is in reality hard to be put into practice. In the case of t=11, 12, α touches 0 with premium available. Though such change failed to alter E(t)=0 for the weakest (t=21), it has enabled MN to function better by reducing E(t) for t=11-14 generation. In other words, more flexible var outperforms con in terms of achieving the purpose of objective function. For instance, the objective function of var valued at−23852 is smaller than−23418 of con.

〈Table 6〉 Health insurance simulation model 1-1: Obj 3 con results

Model 1-1: Obj 3 sum E(t), A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	0.000	0.000	1.000	0.000
12	0.000	0.000	1.000	0.000
13	0.000	-3,133.531	1.000	0.000
14	0.000	-4,375.292	1.000	0.000
15	0.000	-4,417.888	1.000	0.000
16	0.000	-4,268.311	1.000	0.000
17	0.000	-3,855.753	1.000	0.000
18	0.000	-2,658.325	1.000	0.000
19	0.000	-1,039.201	1.000	0.000
20	0.000	160.749	1.000	0.000
21	0.000	168.804	1.000	0.000
sum E(t)		-23,418		

〈Table 7〉 Health insurance simulation model 1-1: Obj 3 var results

Model 1-1: Obj 3 sum E(t), A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	544.701	-264.616	0.000	0.000
12	637.638	-168.805	0.000	0.000
13	0.000	-3,133.531	1.000	0.000
14	0.000	-4,375.292	1.000	0.000
15	0.000	-4,417.888	1.000	0.000
16	0.000	-4,268.311	1.000	0.000
17	0.000	-3,855.753	1.000	0.000
18	0.000	-2,658.325	1.000	0.000
19	0.000	-1,039.201	1.000	0.000
20	0.000	160.749	1.000	0.000
21	0.000	168.804	1.000	0.000
sum E(t)		-23,852		

C) 1-1 vs 1-2 comparison by object

a. Obj 1

- As for con and var, the outcome is identical to that of 1.1. This implies that there is no room for improvement as reserving is allowed.

〈Table 8〉 Health insurance simulation model 1-2: Obj 1 con results

Model 1-2: Obj 1 sum |E(t)|, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	544.701	-723.514	0.000	0.000
12	637.638	-1,179.446	0.000	0.000
13	697.020	-1,793.561	0.000	0.000
14	740.151	-2,323.280	0.000	0.000
15	790.690	-1,808.951	0.000	0.000
16	851.786	-1,387.540	0.000	0.000
17	909.988	-989.573	0.000	0.000
18	976.339	-652.465	0.000	0.000
19	1,048.126	-322.483	0.000	0.000
20	1,127.310	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
sum |E(t)|		11,273		

〈Table 9〉 Health insurance simulation model 1-2: Obj 1 var results

Model 1-2: Obj 1 sum |E(t)|, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	0.000	-458.898	1.000	0.000
12	0.000	-1,010.641	1.000	0.000
13	697.020	-1,793.561	0.000	0.000
14	740.151	-2,323.280	0.000	0.000
15	790.690	-1,808.951	0.000	0.000
16	851.786	-1,387.540	0.000	0.000
17	909.988	-989.573	0.000	0.000
18	976.339	-652.465	0.000	0.000
19	1,048.126	-322.483	0.000	0.000
20	1,127.310	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
sum |E(t)|		10,840		

b. Obj 2

- In the case of con, reserve is set when generation t equals to 11, and 14-19. Premiums rise for the generations who experience the commencing or expanding of reserve. Generations with the reducing or expiring reserve witness their premiums decreasing or hitting 0. (premium 0 for generation t=18-20) E(t) equaling to 0 remains unchanged for the weakest (t=21). Net contribution came in smaller than 1-1 if generation t=11, 14-18, while becoming equivalent to 1.1 in the case of t=19-21. E(t) aggravated only when generation t equals to 12, 13. Reserving not only raised premium but also enhanced net contribution, suggesting that MMI allows net contribution to improve for other generations without being limited to the weakest.

- Var, on the other hand, returns the same premium as con; provided, however, that self contribution α which was 1 in the case of t=14-16 turned 0 with the accumulation of reserve. E(t) remains unchanged at 0 for the weakest (t=21). Only t=11-13 generation witnessed E(t) growing larger than 1-1. It was on equal footing with generation t=19-21 and got better for the remainder. Aside from t=11 perceived as an adjustment period with the inception of reserving, reserve-based generations saw their premium rising yet E(t) improving, too. As for var, MMI enabled net contribution to strengthen for other generations if not limited to the weakest.

〈Table 10〉 Health insurance simulation model 1-2: Obj 2 con results

Model 1-2: Obj 2 Emax, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	1,089.402	-1,690.872	0.000	19,133,699,133.371
12	62.692	-737.072	0.000	0.000
13	697.020	-1,059.391	0.000	0.000
14	1,480.302	-2,810.411	0.000	20,617,252,751.338
15	1,472.726	-3,753.673	0.000	37,967,804,243.880
16	1,703.572	-4,790.443	0.000	58,203,471,844.326
17	1,819.977	-3,378.377	0.000	79,294,443,015.597
18	0.000	-1,642.100	0.000	56,450,198,587.083
19	0.000	-322.483	0.000	30,607,568,936.844
20	0.000	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
Emax		0		

〈Table 11〉 Health insurance simulation model 1-2: Obj 2 var results

Model 1-2: Obj 2 Emax, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	1,089.402	-1,690.872	0.000	19,133,699,133.371
12	62.692	-737.072	0.000	0.000
13	697.020	-1,059.391	0.000	0.000
14	1,480.302	-2,810.411	0.000	20,617,252,751.338
15	1,472.726	-3,753.673	0.000	37,967,804,243.880
16	1,703.572	-4,790.443	0.000	58,203,471,844.326
17	1,819.977	-3,378.377	0.000	79,294,443,015.597
18	0.000	-1,642.100	0.000	56,450,198,587.083
19	0.000	-322.483	0.000	30,607,568,936.844
20	0.000	-92.716	0.000	0.000
21	1,221.420	0.000	0.000	0.000
Emax		0		

c. Obj 3

- In the case of con, reserving takes place when t=11-20. Premiums rise for the generations undergoing the commencement or expansion of reserve. Premiums diminish or become 0 for those with reducing or expiring reserve. Self-contribution α, which stayed at 1 throughout 1-1, is now changed to 0. Meanwhile, E(t) has improved for all generations within the 'planning period.' This suggests that reserving helps foster equalization so as to fulfill the objective function of MN (minimizing net-transfer).
- For var, reserve is set when t=11-20. Premiums soar for the generations with commencing or expanding reserve. Premiums fall or become 0 amid the declining or expiring reserve. (0 when t=15-21) Self-contribution recorded 1 when t=15-18 while marking 0.45 in the case of t=19. Reserve remains unchanged where self-contribution stays

at 1, indicating that MN has a tendency to leverage all possible variables to reduce net contribution. E(t) improved for all generations within the 'planning period.' In that respect, it can be concluded that reserving and self-contribution lead to promoting equalization as intended by the objective function of MN to curtail E(t) as much as possible. Progress achieved by var objective function outstrips that of con.

〈Table 12〉 Health insurance simulation model 1-2: Obj 3 con results

Model 1-2: Obj 3 sum E(t), A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	1,089.402	-1,705.342	0.000	19,133,699,133.371
12	1,275.276	-5,280.989	0.000	40,353,751,078.068
13	1,394.041	-3,602.098	0.000	62,041,159,682.703
14	1,480.302	-4,994.013	0.000	82,658,412,434.041
15	1,581.380	-5,913.595	0.000	102,773,066,730.930
16	1,703.572	-5,195.886	0.000	123,008,734,331.376
17	655.876	-4,657.191	0.000	117,119,127,463.627
18	0.000	-3,233.392	0.000	94,274,883,035.113
19	0.000	-1,394.735	0.000	68,432,253,384.875
20	0.000	-92.716	0.000	37,824,684,448.031
21	0.000	0.000	0.000	0.000
sum E(t)		-36,069		

〈Table 13〉 Health insurance simulation model 1-2: Obj 3 var results

Model 1-2: Obj 3 sum E(t), A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	1,089.402	-1,977.378	0.000	19,133,699,133.371
12	1,275.276	-7,142.277	0.000	40,353,751,078.068
13	1,394.041	-6,838.911	0.000	62,041,159,682.703
14	1,480.302	-6,654.689	0.000	82,658,412,434.041
15	0.000	-5,812.548	1.000	82,658,412,434.041
16	0.000	-4,741.670	1.000	82,658,412,434.041
17	0.000	-4,357.845	1.000	82,658,412,434.041
18	0.000	-3,026.532	1.000	82,658,412,434.041
19	0.000	-1,318.856	0.450	68,432,253,384.875
20	0.000	-92.716	0.000	37,824,684,448.031
21	0.000	0.000	0.000	0.000
sum E(t)		-41,963		

(2) Analysis from Model 2

A) 1-1 vs 2-1 status quo comparison

- Premiums stay smaller than 1-1 until t=16 but begin outpacing when t=17 and onwards. Similar to 1-1, they continue to increase, yet with the pace accelerating. This can be, to some extent, caused by rising discount rate, but it is mainly due to the surging benefits, that is, expenses on supplier's side.
- Net contribution has worsened overall, compared to 1-1 in which E(t) was equal to or smaller than 0. For 2-1, however, it turned into a positive territory except for t=11, 12. Specifically, it deteriorated until t=11-15 before turning around. It appears that surging expenses hurt net contribution. With that said, it is concluded that this is partly driven by the increase in discount rate, but we can't be sure of where the implications of discount rate lie.

〈Table 14〉 Health insurance simulation model 2-1: Status quo results

Model 2-1: Status quo				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-219.293	0.000	0.000
12	86.078	-111.720	0.000	0.000
13	144.456	10.102	0.000	0.000
14	258.034	92.149	0.000	0.000
15	456.827	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000

B) 2-1 Obj 1, Obj 2, and Obj 3 compared against 2-1 status quo

a. Obj 1

- As for con, the outcome is identical to 2-1 status quo. It appears there is no room for improvement in terms of algorithm.
- In the case of var, self contribution soared when t=11, 12 (0.699, 0.441 each) amid the lowering premium. In addition to the existing t=21, net contribution was also pushed down to 0. This suggests that the objective function of MI has worked better here. The objective function of var was decreased to 425, relative to 756 of con, indicating that E(t) is drawing near to 0.

⟨Table 15⟩ Health insurance simulation model 2-1: Obj 1 con results

Model 2-1: Obj 1 sum |E(t)|, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-219.293	0.000	0.000
12	86.078	-111.720	0.000	0.000
13	144.456	10.102	0.000	0.000
14	258.034	92.149	0.000	0.000
15	456.827	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
sum |E(t)|		756		

〈Table 16〉 Health insurance simulation model 2-1: Obj 1 var results

Model 2-1: Obj 1 sum |E(t)|, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	15.181	0.000	0.699	0.000
12	48.098	0.000	0.441	0.000
13	144.456	10.102	0.000	0.000
14	258.034	92.149	0.000	0.000
15	456.827	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
sum |E(t)|		425		

b. Obj 2

- For con, the outcome is identical to 2-1 status quo. It appears there is no room for improvement from an algorithm standpoint.
- In the case of var, self-contribution surged when t=16-19, 21 amid the lowering premium. Other than that, no change was observed in premium. While 2-1 status quo yielded net contribution of 95 when t=15 (the weakest), E(t) here declined to 76 when t=14-19, 21, indicating that the burden of the weakest is shouldered by several generations. This change is designed to accommodate the objective function of MMI for those with least advantage. Also, it is found that MMI brings in a positive effect to other generations as 4 out of 5 generations witnessed their net contribution improving. In that regard, it can be concluded that var facilitates the promotion of equalization intended by the objective function better than con.

〈Table 17〉 Health insurance simulation model 2-1: Obj 2 con results

Model 2-1: Obj 2 Emax, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-219.293	0.000	0.000
12	86.078	-111.720	0.000	0.000
13	144.456	10.102	0.000	0.000
14	258.034	92.149	0.000	0.000
15	456.827	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
Emax		95		

〈Table 18〉 Health insurance simulation model 2-1: Obj 2 var results

Model 2-1: Obj 2 Emax, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-222.323	0.000	0.000
12	86.078	-157.722	0.000	0.000
13	144.456	-0.687	0.000	0.000
14	258.034	76.616	0.000	0.000
15	456.827	76.616	0.000	0.000
16	826.183	70.269	0.006	0.000
17	1,220.891	76.616	0.116	0.000
18	1,944.451	76.616	0.111	0.000
19	2,508.529	76.616	0.262	0.000
20	4,862.862	31.790	0.000	0.000
21	4,814.004	76.616	0.303	0.000
Emax		76		

c. Obj 3

- Both con and var return the same outcome as 2-1 status quo. This means that there is no room for improvement for MN. Limited algorithm prohibits any solutions from making progress for equity.

〈Table 19〉 Simulation model 2-1: Obj 3 con results

Model 2-1: Obj 3 sum E(t), A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-219.293	0.000	0.000
12	86.078	-111.720	0.000	0.000
13	144.456	10.102	0.000	0.000
14	258.034	92.149	0.000	0.000
15	456.827	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
sum E(t)		94		

〈Table 20〉 Health insurance simulation model 2-1: Obj 3 var results

Model 2-1: Obj 3 sum E(t), A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-219.293	0.000	0.000
12	86.078	-111.720	0.000	0.000
13	144.456	10.102	0.000	0.000
14	258.034	92.149	0.000	0.000
15	456.827	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
sum E(t)		94		

C) 2-1 vs 2-2 comparison by Obj

a. Obj 1

- For con, reserve was set when t=11-18, 20. Premiums were on the rise for the generations experiencing the commencement or expansion of reserve. On the contrary, they declined for those with reducing or expiring reserve. A few exceptions are found where reserving begins, ends, or is being adjusted (t=18, 19). There was no self-contribution. Inequity has eased as the objective function marked 0 when t=12-15 amid the varying reserve, aside from the existing t=21. This suggests that reserving policy has contributed to propelling equalization as intended by MI. The objective function was down to 244, compared to 756 of 2-1 con, narrowing the gap existing from the maximum equilibrium of 0.

- As for var, reserving occurs when t=11-18. Premium increase/decrease moves in sync with reserve growth except for adjusting period; provided, however, that for t=19-21 where net contribution should be curtailed, reserve becomes 0, raising premiums. Self-contribution occurs in the case of t=11 (0.344). Consequently, it can be said that the objective function MI has made some headway as the number of generations with net contribution of 0 was added by one (t=11) while of 6 other generations, with the exclusion of one, 3 generations witnessed their E(t) declining with 2 generations remaining unchanged. The objective function was down to 218 from 244. This is a case in point that equity is better served by employing both reserving and self-contribution.

〈Table 21〉 Health insurance simulation model 2-2: Obj 1 con results

Model 2-2: Obj 1 sum |E(t)|, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	100.901	-1.559	0.000	1,772,176,956.482
12	172.155	0.000	0.000	4,636,765,219.449
13	288.912	0.000	0.000	9,131,434,041.464
14	516.069	0.000	0.000	16,319,105,444.837
15	913.654	0.000	0.000	27,940,488,267.162
16	946.391	105.702	0.000	30,678,651,982.747
17	244.818	77.916	0.000	4,331,373,613.854
18	2,350.211	47.701	0.000	8,170,035,761.964
19	3,066.263	5.826	0.000	0.000
20	6,041.908	6.173	0.000	32,012,251,609.300
21	5,868.891	0.000	0.000	0.000
sum |E(t)|		244		

〈Table 22〉 Health insurance simulation model 2-2: Obj 1 var results

Model 2-2: Obj 1 sum |E(t)|, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	66.176	0.000	0.344	1,162,284,737.478
12	172.155	0.000	0.000	4,026,873,000.444
13	288.912	0.000	0.000	8,521,541,822.459
14	516.069	0.000	0.000	15,709,213,225.833
15	655.483	0.000	0.000	20,762,910,384.419
16	1,182.911	79.502	0.000	29,120,015,901.978
17	293.623	66.853	0.000	3,903,894,966.138
18	2,056.991	44.132	0.000	881,860,614.828
19	3,361.857	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
sum |E(t)|		218		

b. Obj 2

- In the case of con, reserve is set when t=11-19. As seen above, premium increase/decrease moves in line with reserve if not adjusting period. There occurred no self-contribution. With the introduction of reserving, the weakest shrank to 43 in case of t=13-14, 16-18, as opposed to 2-1 reaching 95 when t=14. This testifies to the sharing of the pain of the weakest. Net contribution also makes progress in other generations if possible.

- For var, reserving takes place when t=11-19. Premium follows a general tendency mentioned above. Self-contribution arises when t=21 (0.139). This allows the weakest to expand to t=13-18, 20-21, thus spreading the pain. Net contribution also declined to 35, compared to 43 of con.

〈Table 23〉 Health insurance simulation model 2-2: Obj 2 con results

Model 2-2: Obj 2 Emax, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	100.901	-39.178	0.000	1,772,176,956.482
12	172.155	27.816	0.000	4,636,765,219.449
13	288.912	43.085	0.000	9,131,434,041.464
14	516.069	43.085	0.000	16,319,105,444.837
15	913.654	37.755	0.000	27,940,488,267.162
16	788.786	43.085	0.000	26,934,474,040.941
17	1,174.782	43.085	0.000	22,141,139,385.137
18	2,014.147	43.085	0.000	18,116,638,529.464
19	2,713.340	21.563	0.000	1,244,900,899.169
20	4,817.011	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
	Emax	43		

〈Table 24〉 Health insurance simulation model 2-2: Obj 2 var results

Model 2-2: Obj 2 Emax, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	100.901	-48.915	0.000	1,772,176,956.482
12	172.155	-4.824	0.000	4,636,765,219.449
13	288.912	35.192	0.000	9,131,434,041.464
14	516.069	35.192	0.000	16,319,105,444.837
15	913.654	35.192	0.000	27,940,488,267.162
16	741.729	35.192	0.000	25,816,554,771.068

Model 2-2: Obj 2 Emax, A(t)=var.				
17	1,177.502	35.192	0.000	21,086,271,561.506
18	1,866.553	35.192	0.000	13,608,388,720.636
19	2,763.315	29.234	0.028	301,339,168.897
20	4,520.429	35.192	0.068	0.000
21	5,943.249	35.192	0.139	0.000
Emax		35		

c. Obj 3

- For con, reserve was set when t=11, prompting premium to alter. There was no self-contribution. In this case, no change was found in MN. The objective function was valued at 94, identical to 2-1.
- In the case of var, reserving occurs when t=11-14, with premiums changing as stated above. There was no self-contribution. With the change of variable, better equity was achieved for MN, relative to con. The objective function value plunged to -64, compared to 94 of con.

〈Table 25〉 Health insurance simulation model 2-2: Obj 3 con results

Model 2-2: Obj 3 sum E(t), A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	100.901	-219.293	0.000	1,772,176,956.482
12	32.826	-111.720	0.000	0.000
13	144.456	10.102	0.000	0.000
14	258.034	92.149	0.000	0.000
15	456.827	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
sum E(t)		94		

〈Table 26〉 Health insurance simulation model 2-2: Obj 3 var results

Model 2-2: Obj 3 sum E(t), A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	100.901	-213.093	0.000	1,772,176,956.482
12	172.155	-187.316	0.000	4,636,765,219.449
13	288.912	-79.266	0.000	9,131,434,041.464
14	347.423	92.149	0.000	11,621,382,822.325
15	0.000	95.159	0.000	0.000
16	831.132	87.956	0.000	0.000
17	1,381.595	68.078	0.000	0.000
18	2,186.150	44.132	0.000	0.000
19	3,397.624	21.563	0.000	0.000
20	4,862.862	6.173	0.000	0.000
21	6,902.618	0.000	0.000	0.000
sum E(t)		-64		

(3) Analysis from Model 3

A) 2-1 vs 3-1 status quo comparison

- Compared to 2-1 status quo, premiums remain unchanged while all net contributions turned into negative, smaller numbers. This was achieved only by the rising discount rate, suggesting that a hike in discount rate could lead to the expansion of equity. However, given that the existing German research argues that the soaring discount rate has undermined net contribution (Schulenburg, 1987), it can be concluded that finding any generic patterns for discount rate is unlikely.

〈Table 27〉 Health insurance simulation model 3-1: Status quo results

Model 3-1: Status quo				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-293.567	0.000	0.000
12	86.078	-212.042	0.000	0.000
13	144.456	-140.563	0.000	0.000
14	258.034	-93.584	0.000	0.000
15	456.827	-77.653	0.000	0.000
16	831.132	-69.103	0.000	0.000
17	1,381.595	-66.137	0.000	0.000
18	2,186.150	-65.011	0.000	0.000
19	3,397.624	-63.041	0.000	0.000
20	4,862.862	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000

B) 3-1 Obj 1, Obj 2, and Obj 3 compared against 3-1 status quo

a. Obj 1

- Premiums were lowered for both con and var, with self-contribution increasing throughout the entire generations. The objective function value also diminished as intended by the direction of MI. Particularly, in the case of var, all E(t)s were changed into 0, striking a perfect balance between generations. This implies that improving equity is enabled by curtailing premium and raising self contribution amid high discount rate.

〈Table 28〉 Health insurance simulation model 3-1: Obj 1 con results

Model 3-1: Obj 1 sum |E(t)|, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	16.585	-96.505	0.671	0.000
12	28.297	-69.706	0.671	0.000
13	47.488	-7.671	0.671	0.000
14	84.825	14.712	0.671	0.000
15	150.174	10.374	0.671	0.000
16	273.221	0.641	0.671	0.000

Model 3-1: Obj 1 sum |E(t)|, A(t)=const.				
17	454.177	0.000	0.671	0.000
18	718.661	6.074	0.671	0.000
19	1,116.913	10.717	0.671	0.000
20	1,598.586	12.119	0.671	0.000
21	2,269.123	-5.025	0.671	0.000
sum |E(t)|		233		

〈Table 29〉 Health insurance simulation model 3-1: Obj 1 var results

Model 3-1: Obj 1 sum |E(t)|, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	3.983	0.000	0.921	0.000
12	2.952	0.000	0.966	0.000
13	39.394	0.000	0.727	0.000
14	102.068	0.000	0.604	0.000
15	190.011	0.000	0.584	0.000
16	309.353	0.000	0.628	0.000
17	473.896	0.000	0.657	0.000
18	831.956	0.000	0.619	0.000
19	1,312.975	0.000	0.614	0.000
20	2,416.061	0.000	0.503	0.000
21	1,790.218	0.000	0.741	0.000
sum |E(t)|		0		

b. Obj 2

- When compared against 3-1 status quo, premium, self-contribution, and the weakest yielded identical results for both con and var. This suggests that the change of discount rate alone can't alter the weakest.

〈Table 30〉 Health insurance simulation model 3-1: Obj 2 con results

Model 3-1: Obj 2 Emax, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-293.567	0.000	0.000
12	86.078	-212.042	0.000	0.000
13	144.456	-140.563	0.000	0.000
14	258.034	-93.584	0.000	0.000
15	456.827	-77.653	0.000	0.000

Model 3-1: Obj 2 Emax, A(t)=const.				
16	831.132	-69.103	0.000	0.000
17	1,381.595	-66.137	0.000	0.000
18	2,186.150	-65.011	0.000	0.000
19	3,397.624	-63.041	0.000	0.000
20	4,862.862	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
Emax		-53		

〈Table 31〉 Health insurance simulation model 3-1: Obj 2 var results

Model 3-1: Obj 2 Emax, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-293.567	0.000	0.000
12	86.078	-212.042	0.000	0.000
13	144.456	-140.563	0.000	0.000
14	258.034	-93.584	0.000	0.000
15	456.827	-77.653	0.000	0.000
16	831.132	-69.103	0.000	0.000
17	1,381.595	-66.137	0.000	0.000
18	2,186.150	-65.011	0.000	0.000
19	3,397.624	-63.041	0.000	0.000
20	4,862.862	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
Emax		-53		

c. Obj 3

- Similar to Obj 2 above, both con and var returned the same values as 3-1 status quo. There is no room for improvement.

〈Table 32〉 Health insurance simulation model 3-1: Obj 3 con results

Model 3-1: Obj 3 sum E(t), A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-293.567	0.000	0.000
12	86.078	-212.042	0.000	0.000
13	144.456	-140.563	0.000	0.000
14	258.034	-93.584	0.000	0.000
15	456.827	-77.653	0.000	0.000
16	831.132	-69.103	0.000	0.000
17	1,381.595	-66.137	0.000	0.000

Model 3-1: Obj 3 sum E(t), A(t)=const.				
18	2,186.150	-65.011	0.000	0.000
19	3,397.624	-63.041	0.000	0.000
20	4,862.862	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
sum E(t)		-1,193		

〈Table 33〉 Health insurance simulation model 3-1: Obj 3 var results

Model 3-1: Obj 3 sum E(t), A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-293.567	0.000	0.000
12	86.078	-212.042	0.000	0.000
13	144.456	-140.563	0.000	0.000
14	258.034	-93.584	0.000	0.000
15	456.827	-77.653	0.000	0.000
16	831.132	-69.103	0.000	0.000
17	1,381.595	-66.137	0.000	0.000
18	2,186.150	-65.011	0.000	0.000
19	3,397.624	-63.041	0.000	0.000
20	4,862.862	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
sum E(t)		-1,193		

C) 3-1 vs 3-2 comparison by Obj

a. Obj 1

- When comparing with 3-1, the rising discount rate allowed both con and var to strengthen equity through the adoption of reserve and self-contribution.

〈Table 34〉 Health insurance simulation model 3-2: Obj 1 con results

Model 3-2: Obj 1 sum |E(t)|, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	19.367	-39.679	0.616	0.000
12	33.044	-51.237	0.616	0.000
13	110.908	0.000	0.616	1,725,418,478.731
14	198.109	8.228	0.616	4,484,629,790.960
15	350.734	0.000	0.616	8,945,859,186.068
16	287.652	0.000	0.616	8,199,800,002.467

Model 3-2: Obj 1 sum |E(t)|, A(t)=const.				
17	585.836	0.000	0.616	9,485,385,029.769
18	712.380	0.000	0.616	6,517,564,152.662
19	1,389.931	0.000	0.616	8,629,298,323.567
20	2,768.822	6.256	0.616	33,121,160,670.668
21	1,580.249	-9.019	0.616	0.000
sum |E(t)|		114		

〈Table 35〉 Health insurance simulation model 3-2: Obj 1 var results

Model 3-2: Obj 1 sum |E(t)|, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	3.687	0.000	0.927	0.000
12	9.777	0.000	0.886	0.000
13	44.036	0.000	0.695	0.000
14	201.179	0.000	0.610	2,801,967,835.802
15	150.580	0.000	0.429	0.000
16	425.882	0.000	0.488	0.000
17	499.008	0.000	0.639	0.000
18	1,146.251	0.000	0.738	13,409,903,666.486
19	2,625.950	0.000	0.614	45,782,664,154.131
20	729.836	0.000	0.503	0.000
21	1,790.218	0.000	0.741	0.000
sum |E(t)|		0		

b. Obj 2

- Compared to 3-1, the rising discount rate triggered reserve and premium to change for both con and var, but with the weakest (t=23) remaining unchanged, there was no improvement made in equity under such inevitable circumstances. Overall, other generations stand to gain depending on how MMI principle is operated.

〈Table 36〉 Health insurance simulation model 3-2: Obj 2 con results

Model 3-2: Obj 2 Emax, A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-245.612	0.000	0.000
12	86.078	-181.685	0.000	0.000
13	144.456	-70.889	0.000	0.000
14	258.034	-87.458	0.000	0.000
15	913.654	-53.642	0.000	11,621,382,822.325
16	341.950	-83.664	0.000	0.000
17	2,763.189	-62.536	0.000	32,021,477,007.882
18	817.585	-74.294	0.000	0.000
19	4,778.449	-63.041	0.000	34,045,691,824.521
20	3,608.923	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
Emax		-53		

〈Table 37〉 Health insurance simulation model 3-2: Obj 2 var results

Model 3-2: Obj 2 Emax, A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	50.451	-245.612	0.000	0.000
12	86.078	-181.685	0.000	0.000
13	144.456	-70.889	0.000	0.000
14	258.034	-87.458	0.000	0.000
15	913.654	-53.642	0.000	11,621,382,822.325
16	341.950	-83.664	0.000	0.000
17	2,763.189	-62.536	0.000	32,021,477,007.882
18	817.585	-74.294	0.000	0.000
19	4,778.449	-63.041	0.000	34,045,691,824.521
20	3,608.923	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
	Emax	-53		

c. Obj 3

- Relative to 3-1, the surging discount rate prompted a change in premium to match against reserving for both con and var. However, there was no change in self-contribution. No equity improvement was found for con, as opposed to var which witnessed some progress in equity.

〈Table 38〉 Health insurance simulation model 3-2: Obj 3 con results

Model 3-2: Obj 3 sum E(t), A(t)=const.				
t	B(t)	E(t)	A(t)	F(t)
11	100.901	-293.567	0.000	1,772,176,956.482
12	32.826	-212.042	0.000	0.000
13	144.456	-140.563	0.000	0.000
14	258.034	-93.584	0.000	0.000
15	456.827	-77.653	0.000	0.000
16	831.132	-69.103	0.000	0.000
17	1,381.595	-66.137	0.000	0.000
18	2,186.150	-65.011	0.000	0.000
19	3,397.624	-63.041	0.000	0.000
20	4,862.862	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
sum E(t)		-1,193		

〈Table 39〉 Health insurance simulation model 3-2: Obj 3 var results

Model 3-2: Obj 3 sum E(t), A(t)=var.				
t	B(t)	E(t)	A(t)	F(t)
11	100.901	-304.384	0.000	1,772,176,956.482
12	172.155	-274.500	0.000	4,636,765,219.449
13	288.912	-149.623	0.000	9,131,434,041.464
14	0.000	-93.584	0.000	1,943,762,638.090
15	380.419	-77.653	0.000	0.000
16	831.132	-69.103	0.000	0.000
17	1,381.595	-66.137	0.000	0.000
18	2,186.150	-65.011	0.000	0.000
19	3,397.624	-63.041	0.000	0.000
20	4,862.862	-59.237	0.000	0.000
21	6,902.618	-53.642	0.000	0.000
sum E(t)		-1,275		

Chapter 5

Conclusion and Policy Implications

5 Conclusion and Policy Implications

Finally, we will review political implications to enhance intergenerational equity in social welfare defined in our analysis. Previously, it was mentioned that the equity-boosting solutions in terms of financing pursued by our study are driven by the direction of funding that enables equilibrium.

Overall, the three concepts of equity, namely, minimizing inequity (MI), minimizing maximum inequity (MMI), and minimizing net-transfer (MN), have their own unique features without exhibiting any univocal excellency (i.e. both generation-specific and total sum kept at minimal level). So, which to choose should be left to the decision-making of a society; provided, however, that given the increasing importance of financial sustainability, the concept of MI may carry more significance.

The following briefly describes the implications of financing policy variables:

〈Reserve〉

- Premiums rise for the generations in which reserving takes off or expands. They diminish or become 0 for those with reducing or expiring reserve. A few exceptions are observed where reserving begins, ends or gets adjusted.

- When reserve is set, premiums are on the rise, yet net contribution improves, too. A few exceptions are found where reserving begins, ends or gets adjusted.
- Reserving helps boost the purpose of each objective function aiming for better equity.

〈Self-contribution〉

- In terms of self contribution, var is more effective in accommodating the purpose of each objective function seeking equity, relative to con.

〈Premium〉

- Premium (or tax) is determined structurally by the concept of equity materialized by the optimization of the linear programming model. Generally, it fails to exhibit any specific characteristics corresponding to the concept of equity, but it is clear that adjustment of premium is required to accomplish equity.
- Surging expenses, compounded by the aggravating net contribution, increase premium rapidly.
- If self-contribution is raised to improve E(t), premium declines.

〈Other overall implications〉

- MMI works toward not only having the burden of the weakest shared by others but also enhancing the conditions of other generations.
- There may exist no room for improvement depending on equity solutions. In such limited circumstances, the introduction of a policy may make no difference in terms of boosting equity.
- Equity can be better achieved if reserving and self contribution are put in place together.

〈Implications of discount rate〉

- There were cases in which net contribution improved with larger discount rate applied. Yet, as some existing studies specify otherwise, it can be said that there is no generic rule defined here. In a word, it affects differently depending on generations.

〈Policy direction factoring in the characteristics of policy tool〉

- A look at the age-based tax profile reveals that income tax forms a more clear 'U' shape than consumption tax. This suggests that consumption tax is deemed inappropriate as a policy tool if the cross-generational equity problem arises due to the transfer of income into old age (Gun-Chun Ryu, et al. 2013, 153-155).

As consumption tax inflicts an increasing burden on the elderly recently, it can be used as a means of improving equity between generations.

〈Achievements and Limitations of the Study〉

Compared to the previous studies, this study has accomplished different achievements as specified below:

First, it has successfully provided a specific illustration of intergenerational equity concepts relating to the social welfare function. Also, unlike the existing studies that simply offered the outcome of research only, the study has clarified the characteristics of each cross-generational equity concept as well as its strengths and weaknesses.

Second, it has demonstrated that the existing research method can't be applied if net contribution is used as a measure of equity between generations. So, as a workaround, the linear simulation model was employed to identify the burden fulfilling the concept of intergenerational equity, before developing funding solutions with the nature of cross-generational equity in terms of financing taken into account.

Third, this study has embraced generational accounting that matches the concept of intergenerational equity by deploying linear simulation model.

Nevertheless, the study has some limitations as listed below, which should be addressed through follow-up research:

First, much effort is required to make the current linear simulation model more realistic. Despite close communication between the researcher and the modeller who ran the calculation, reflecting all the intentions of the researcher was limited. Thus, it is vital to work toward resolving such a limitation through follow-up studies.

Second, policy implications identified through simulation usually lack in universality as opposed to analytical or metempirical results. That being said, such a limitation should be taken into consideration upon implementation.

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