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EFFECT OF MORTALITY IMPROVEMENT ON THE BUDGET PROJECTION OF THE BASIC PENSION IN KOREA

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ABSTRACT

In Korea, basic pension provides a stable income to the elderly who have low saving to live in their post retirement period. Given the worsening longevity risk and aging problem in Korea, sustainability of the basic pension system is of great importance. Therefore, this study investigates how the budget projection of the basic pension system will be impacted by different assumptions on the mortality improvement. We employ several previously published mortality tables to derive different speed of mortality improvement. Subsequently, we apply the estimated future mortality rates to forecast the number of elderly populations as well as the future budget projections. Our results reveal substantial differences in budget projections depending on the assumptions of the mortality improvement, indicating that correct forecast of the mortality rates is the key to budget projection of the pension system.

MAIN PAPER STARTS HERE…

Introduction

Recently, the longevity risk, the risk of outliving retirement assets (Albrecht and Maurer, 2002), has increased enormously in Korea. Specifically, the low birth rate and the low interest rate have become a serious threat to the stability of the financial income of retirees (Andersen, 2008). These are the two most crucial factors: First, as the low birth rate leads to a severe aging problem of the society, government can only raise smaller tax revenue while the public system requires higher government spending than before. Second, the recent low interest rate has caused an overall low expected rate of return of the retirement assets, which has led to a lower accumulation of the retirement wealth. The combined effects are significant as the elderly poverty rate in Korea reached 43.4% in 2018, indicating that almost half of the Korean elderly population has insufficient income level during their retirement phases.

From the government's perspective, this aging problem may lead to a very undesirable situation in terms of the budget planning for the future public spending (European Commission, 2003). If an elderly does not have enough income, they will not care about the health status themselves and this would incur higher medical costs compared to the average elderly population, which will be eventually reimbursed by the government spending through the public medical systems. Hence, the Korean government implemented the basic pension system in 2008 to alleviate this issue, which aims to provide a certain amount of income stream for those who are suffering from insufficient level of income during the post-retirement period (Pak, 2021). The basic pension system is a mean-tested income support program, meaning that about 67% of the elderly population is eligible (Lee and Wolf, 2014). However, although the ratio of the basic pension recipients out of total elderly population is fixed approximately 67%, the number of recipients is quickly increasing due to the aging problem. Therefore, it is of great importance to correctly predict the number of future elderly population to perform the budget projection of the basic pension system (Tian and Zhao, 2016). This would help the government to make a plausible plan to financially support the elderly people and to maintain the sustainability of the system at the same time.

In this study, we investigate how the budget projection of the basic pension system in Korea would be affected by different assumptions on the mortality improvement. A mortality improvement measures the changes in mortality rates over time, and usually the change means reduction because the mortality rates tend to decrease due to better living standard and better health status. The mortality improvements may vary between different age cohorts of the population, and hence it requires an exact estimation of different age groups. Furthermore, we should also separately estimate the mortality improvement of the male and female elderly population as the mortality rates show substantial differences by gender groups as well. As demonstrated by Lee and Tuljapurker (1998) and Lee and Yamagata (2003), this mortality improvement estimation is the most crucial factor in budget projection of the basic pension system as it provides us about the number of elderly populations in future years.

By employing the estimation method of Fong et al. (2011), which is a simpler version of the Lee and Carter (1992) model, we extensively measure the mortality improvements of the average elderly populations per age group, based on different published years of the life tables. Applying the estimates on the current elderly population yields a multiple of future projections of the elderly populations, allowing us to illustrate the uncertain possible range of the projection with the upper and lower bound of population over the years. We then set up two scenarios for the level of pension payments: i) a flat payment of KRW200,000 and ii) a 50% increase from KRW200,000 to KRW300,000 in 2025. Combining these, we computed the budget projection of the basic pension system until 2085.

This study proceeds as follows. Section 2 presents our theoretical model and the research methodology, and the results are discussed in Section 3. Section 4 concludes with some policy implications.

Methodology

Mortality Rates of Population

To determine the number of populations expected to survive in future periods, we must transform the survival probabilities provided in the period life table into the cohort ones. We first denote $p_x(j)$ the probability that a person aged x in year j survives one year to age $x+1$. Note that p_x only provides information on a 1-year survival probability; however, we need cumulative survival rates over a longer horizon. Hence, we further define a t-year survival probability ${}_tP_x(j)$:

$$ {}_tP_x(j) = \prod_{i=1}^{t} p_{x+i-1}(j), \quad (1) $$

where ${}_tP_x(j)$ denoted the probability that a person aged x in year j lives for another t years to age $x+t$. This equation (1) states that the t-year cumulative survival probability is obtained by a product of one-year survival probabilities during t years.

Estimation of Mortality Improvement

Mortality improvement measures the change in survival probabilities over time. As a country develops and the economy grows, medical services and social infrastructures become more accessible to the population and the overall health status improves. This leads to a mortality improvement with the reduction in the mortality rates over the years. Hence, mortality improvement is a key element to be identified when constructing a cohort life table from a period life table. To cohortize the period population table, we employ the methodology of Fong et al. (2011) as follows:

$$q_x(j+t) = q_x(j) \cdot \beta_x^t, \quad (2)$$

where $q_x(j)$ is the one-year mortality rate of a person aged x in year j and satisfies the relation $q_x(j) = 1 - p_x(j)$, and β_x measures the yearly mortality improvement. Here the estimation in (2) must be based on the mortality rates of the two existing period tables in the year j and the year $j + t$; furthermore, the length of t depends on the length of horizon a researcher would want to estimate the effect of mortality improvement. Using the estimated coefficient β_x, we can construct the projected future mortality rate:

$$\hat{q}_x(k+t) = q_x(k) \cdot \beta_x^t, \quad (3)$$

where $\hat{q}_x(k+t)$ denotes the estimated cohort mortality rate of a person aged x in year $k + t$. Herein, k implies the latest available year of the life table and t is the projected year of interest. It is usually satisfied that $\hat{q}_x(k+t) < q_x(k)$, i.e., future estimated probability of death is lower than the one in the past.

Estimation of Budget Projection of Basic Pension Expenditure

Two types of parameters are required to estimate the budget projection of the basic pension expenditure. First, we need to calculate the expected number of populations who are eligible for the basic pension in the future. This can be done by multiplying cumulative survival probabilities to the population data of each age and sum up the number of populations for the age above 65. Typically, we compute the projected populations based on the following equation:

$$\hat{l}_x(j+t) = l_x(j) \cdot {}_t\hat{p}_x(j), \quad (4)$$

where $l_x(j)$ is the number of populations at age x in year j, ${}_t\hat{p}_x(j)$ is the estimated t-year survival probability in year j, and $\hat{l}_x(j+t)$ is the projected number of populations at age x in year $j + t$. Thus, we can forecast the expected number of survivors at each age in the future. Finally, the budget projection is computed by multiplying the expected number of recipients of the basic pension and the amount of basic pension given to the recipients:

$$B(h) = \tau(h) \cdot \sum_{x=65}^{100} \hat{l}_x(h) \cdot b(h), \quad (5)$$

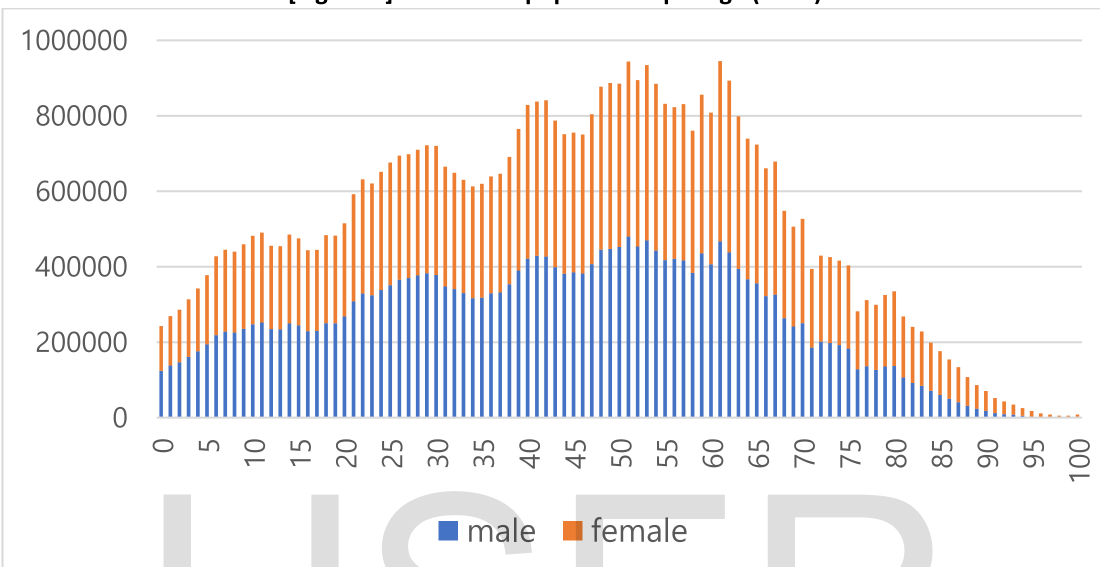
where $B(h)$ is the total projected budget of the basic pension expenditure in year h, $\tau(h)$ is the ratio of basic pension recipients out of the elderly populations above 65, and $b(h)$ is the amount of the basic pension in year h.

Data Used in the Analysis

We employ the complete life tables from 1970 to 2020 published by Statistics Korea. The complete life table is published annually and contains the mortality rate of the average population, covering the age from 0 to 100. We set up the complete life table in 2020 as the latest available table in the mortality improvement estimation, and the table in 1970, 1980, 1990, 2000, and 2010 as the starting year, respectively. Thus, we estimate mortality improvements using various time windows. This will help us test different speed of mortality improvements, providing plausible projections of the budget needed to sustain the basic pension system.

For the number of populations per age, we use the population data also available in Statistics Korea. The most recent data is based on the population as of 2020, as presented in [Figure 1]. We observe that the ratio of male population starts to decrease in older ages due to higher mortality rates, and at extreme ages (over 90) there are almost no male survivors and thus the female population dominates.

[Figure 1] Number of populations per age (2020).



The remaining parameters are the coverage ratio $\tau(h)$ and the basic pension amount $b(h)$. Since the basic pension is a means-tested system, the Korean government sets up the maximum income to be eligible for the basic pension such that 70% of the elderly population would receive the payments. Therefore, elderly people whose income levels are higher than the 70th percentile are not eligible for the basic pension. Hence, we set $\tau(h) = 70\%$. For the pension amount $b(h)$, we apply two scenarios. First, we assume that the current benefit level remains constant in the future periods, i.e., $b(h)$ = KRW200,000. This scenario postulates that an attempt to increase the pension benefit would be rejected due to the lack of budget. Second, we assume that the benefit of the basic pension increases to KRW300,000 as of 2025. This reflects the ongoing discussion between the government and political parties in Korea on whether to increase the benefit level to improve the income stability of elderly populations. To summarize, the parameters and their data source used in our analyses are reported in [Table 1].

[Table 1] Parameters used in the analyses.

Parameter	Description	Source/Value
$p_x(j)$	Survival probability at age x (p_x)	Complete life table
$p_x(j)$	Data year of life table (j)	1970, 1980, 1990, 2000, 2010, 2020
l_x	Number of populations at age x	Statistics Korea
$\tau(h)$	Coverage ratio out of total elderly population	70%
$b_1(h)$	Benefit level (Scenario 1)	KRW200,000
$b_2(h)$	Benefit level (Scenario 2)	KRW200,000/KRW300,000

Discussion

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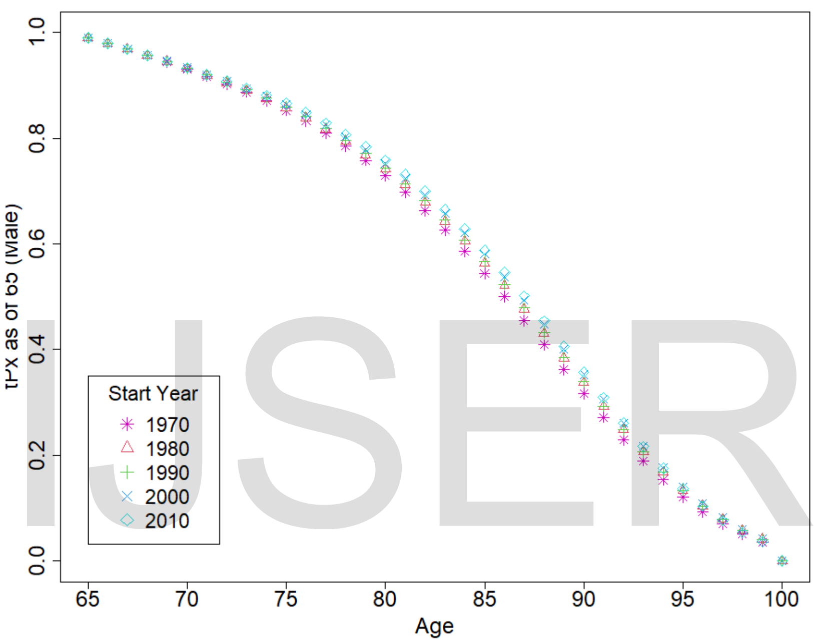
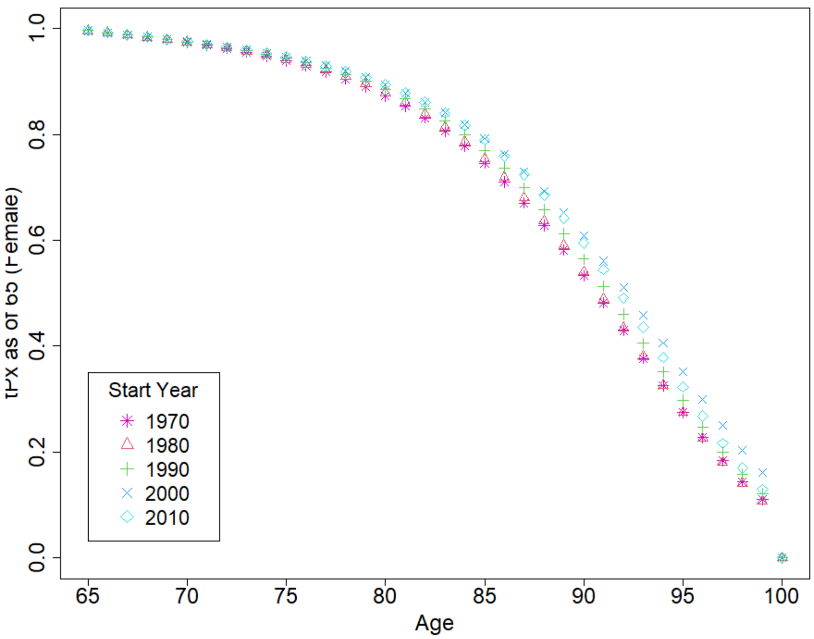
Cohort Survival Rates of the Populations

We first illustrate the effect of mortality improvements on the survival probabilities of both male and female populations in Korea. Since the mortality improvements are better observed in the older population than the younger population, we present the cumulative survival probabilities of a person aged 65. As previously stated, we estimate different mortality improvements using the start year of 1970, 1980, 1990, 2000, and 2010 while fixing the last observed table as 2020. We compare the cumulative survival probabilities of male and female populations in [Figure 2] and [Figure 3].

[Figure 2] Cumulative survival probabilities of a person aged 65 with different mortality improvement rates (male).



[Figure 3] Cumulative survival probabilities of a person aged 65 with different mortality improvement rates (female).



It is observed that for male population, the mortality improvement is the lowest and highest when the estimation is based on life tables in the 1970 and 2020 and in the 2010 and 2020, respectively. For female population it is similar except for the fact that the mortality improvement is the highest when the estimation is based on life tables in 2000 and 2020.Thus, this implies that the speed of mortality improvement is the fastest recently for the male population, whereas it has become a bit slower for the female population. This can be further explained by relatively higher life expectancy of female population compared to the male population in Korea, indicating that the fastest increase in survival probabilities happened in the 2000s for the female population and thus there is not much left to be improved. Therefore, these are reasonable results given that the mortality improvement usually becomes faster as a country develops. Our result confirms that the mortality rate has been rapidly reduced particularly in recent decades in Korea.

We also observe that the mortality improvement is more pronounced in females, particularly at the extreme ages over 90. In the case of males, the cohortized survival probabilities do not exhibit much variation regardless of the difference in the calendar years of the mortality tables used in the estimation. The gaps among the different cumulative survival rates at the same age are quite smaller in the male population. For instance, for a person aged 65, the probability of being alive at the age of 90 is 31.7% if the starting year is 1980 while it is 35.8% if the starting year of 2010 for male population, showing a 4.1%p difference. Meanwhile, the difference is 7.5% p for female population where the cumulative survival rates are 53.3% and 60.8% when the starting year is 1980 and 2000, respectively. This suggests that there is higher uncertainty in future mortality rates of the female population depending on the time window in the estimation of the mortality improvement. Moreover, it might also be that the variation in the budget projection of the basic pension would be higher because of the uncertainty in the projected female population.

Projection of the Elderly Population with Mortality Improvement

In this section, we estimate the future population range based on the cohort mortality rates incorporating the mortality improvement. Figure 4 illustrates the expected number of elderly populations projected from 2023 to 2085. In 2023, the elderly populations is expected to reaches 10 million for the first time, which would be in total about 10.4 million. As depicted in the figure, the slope is the highest during the early years of the projection. In our estimation, the elderly population rapidly grows by 4% every year during 2023–2035, suggesting that the government should prepare enough budget for the basic pension to maintain the social security system. The projected elderly population reaches its peak in 2048, resulting in 18.4 million which is twice as compared to the number in 2023. Note that our estimates concur with the prediction of Statistics Korea as it announced that the elderly population will peak in 2049 with about 19 million, depicting only a small deviation from our result. Hence, it is confirmed that the numbers in our projection are reasonably estimated. After this peak, the elderly population is expected to gradually decrease over time and it will start to decrease more rapidly from 2064.

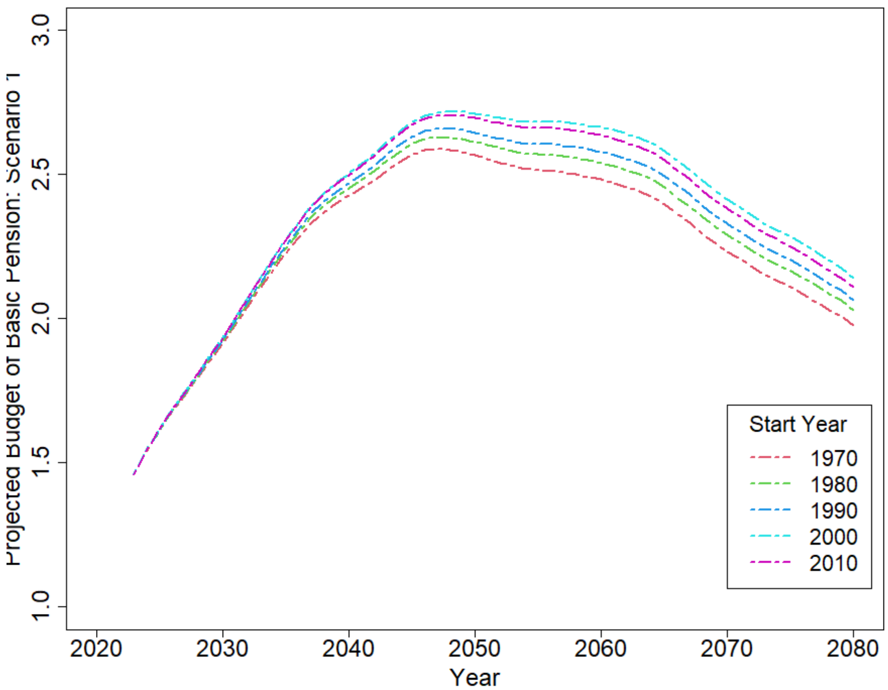
Until 2035, the projected numbers of the elderly population at the same age do not vary much depending on the mortality improvement. However, the projected population after 2035 shows huge differences between estimated numbers, indicating that the assumption of the speed of mortality improvements play a significant role in the projection in later periods. Furthermore, the difference between the maximum and minimum estimates of the elderly populations is approximately 0.16 million in 2030, whereas the difference increases to 1.04 million in 2050. This can be explained by our previous results in [Figure 3] that the effects of the mortality improvement are substantial in female population, implying that the differences in the estimated number of populations are mainly based on the female population. Hence, it can be said that choosing a correct speed of mortality improvement is more important in projecting female population than male population in Korea, due to the higher uncertainty behind the survival rates.

[Figure 4] Projected elderly population with different mortality improvement rates.

Budget Projection of the Basic Pension Expenditure

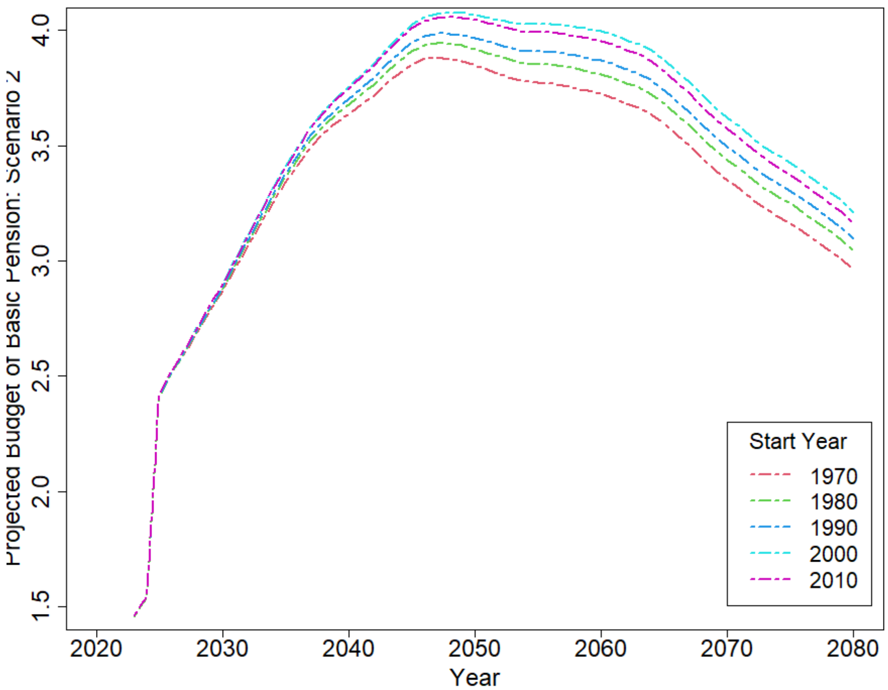
Considering the projected number of elderly populations reported in the previous section, we finally report the budget projection of the basic pension expenditure in Korea. We present two cases on different scenarios: i) a flat benefit of KRW200,000 per person and ii) benefit increases from KRW200,000 to KRW300,000 in 2025, and flat afterwards. By combining the results so far along with the parameters as explained in [Table 1], we estimate that the total budget projection for the basic pension per year using the equation (5). First, [Figure 5] shows the budget projection based on the first scenario where the pension benefit is flat over time.

[Figure 5] Budget projection of the basic pension expenditure with different mortality improvement rates: scenario 1 (2023–2080).



We see that the budget projection of the scenario 1 exactly follows the shape of the projected elderly population in [Figure 4], as it is assumed that 70% of the elderly population will receive the pension benefit which is constant over time. The initial budget expected to be needed in 2023 is KRW1.24 trillion, approximately 0.2% of the budget passed by the National Assembly this year. It reaches KRW2 trillion in 2031, and the estimates start to diverge gradually, indicating an increasing gap in the budget projection for longer horizon. In 2048 when the number of elderly populations is expected to be the highest, the budget projection is in the range of KRW2.58 trillion to KRW2.71, which is approximately 0.42%–0.45% of the government spending in Korea as of 2022. Here, the difference in budget projection is approximately 7.1% in 2048 and it enlarges significantly in the later periods. For instance, the maximum difference in the budget projection estimated in our analysis is in 2065, revealing a 9.04% of difference (KRW0.18 trillion). The overall results suggest that significant pressure will be given to the basic pension system in Korea even if the government decides not to increase the benefit level and keep it constant over the next 60 years. Moreover, [Figure 6] presents the budget projection under a more challenging assumption where the pension payment is increased by 50% from 2025.

[Figure 6] Budget projection of the basic pension expenditure with different mortality improvement rates: scenario 2 (2023–2080)



If the basic pension payment is set up as KRW300,000 from 2025 onward, this would lead to a sharp increase in the budget required to maintain the system. This is visible in the figure particularly by the skyrocketing line around 2025, which can be attributed to the combined effect of increasing elderly population and the increased pension amount. In 2026, the estimated budget of the basic pension is in the range of KRW2.51 trillion to KRW2.53 trillion, which is already above the level of most of the projected budget amounts in [Figure 1]. When the elderly population peaks in 2048, it is predicted that the government spending required for the basic pension payment would be approximately KRW3.88–4.08 trillion, which is approximately 0.64%–0.67% of the national budget in 2022. Our budget projection in scenario 2 suggests that the effect of increasing the benefit level of the basic pension on the overall budget projection is not negligible. Nevertheless, it should be also noted that an increase in basic pension benefit may also lead to a decrease in the government spending on other social security systems as an individual might require less financial support from the society if he or she receives higher benefit from the basic pension. Hence, our results do not provide any information on whether it is more appealing to increase the benefit level or not. The analyses in this study rather emphasize the effect of mortality improvement on the budget projection, which gives higher uncertainty in estimates especially after 2050, indicating the importance of correct estimation of the speed of mortality improvement which varies depending on the year of the life table used in the estimation.

Conclusion

In this study, we explore the effect of mortality improvement on the future budget projection of the basic pension system in Korea. By using different published years of the life table as the starting year of estimation, we derive several scenarios of how the number of elderly populations would evolve over time. Combining with the hypothetical payment assumptions we made, we investigate different paths of the budget projection until 2085. Under the flat payment scenario, we predict that the highest yearly budget required for the basic pension system would be in the range of KRW2.58 trillion to KRW2.71 in 2048, resulting in a maximum of 7.1% difference between predictions. Conversely, under the increasing payment scenario, it is expected that the yearly budget would be in the range of KRW3.88 trillion to KRW4.08 trillion. These projections are approximately 0.4%–0.7% of the national budget of Korea in 2022, implying that an increase in the basic pension benefit may substantially affect the overall budget planning of the government.

Our study has several limitations. First, we do not allow for a stochastic process in the mortality estimation, and we estimate the average speed of mortality improvement by each age cohort and gender and generate a single-line prediction without uncertainty. Allowing for a stochastic process would enrich the estimation and would allow us to explore a wider range of uncertainty in mortality projection. Second, we do not include the potential distortion effect of coronavirus disease 2019 (COVID-19) on the mortality rates particularly on elderly populations. The mortality rates of elderly populations in 2019, 2020, and 2021 would be somewhat different from those of other years since COVID-19 has significant impact of the death of elderly people. However, the current data is limited and therefore we did not incorporate this aspect. Lastly, we test only two possible scenarios for the level of the basic pension payment. It is obvious that different assumptions on the payment level would lead to different budget projections. Therefore, future studies on these potential extensions are recommended.

Our study has several limitations. First, we do not consider time-varying fraction of the risky investment. In practice, a growing attention is given to TDFs (Target Date Funds) which features a decreasing risky investment path until retirement. The results of our analyses based on the utility and probability measure would be different if we allow the time-varying risky fraction of the investment. Second, we do not incorporate survival probabilities of individuals. By including the mortality rates in our model, we will be able to specify optimal investment strategies to different group of populations based on the mortality data. Third, we only look at the period before retirement, i.e., accumulation phase. It would be also interesting to evaluate the optimal investment strategy over the full life-cycle including the post-retirement period. Therefore, it is recommended that further research should be undertaken to investigate these aspects.

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