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Does Migration Result in Mortality Improvement: A Case Study in Taiwan

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Abstract

Mortality reduction has been a common phenomenon at all ages in almost all countries. The trend of mortality improvement usually differs across geographic areas. Generally speaking, mortality rates and mortality improvement in urban areas are lower than those in rural areas, possibly due to the factors such as better living conditions and medical care. The ignorance of the migration effect can cause bias on long-term mortality projection, resulting in financial insolvency of commercial and social insurance.

This study mainly aims to measure the impact of rural to urban migration on mortality improvements and their trends in both rural and urban mortalities, based on the data from Taiwan's public pension system (National Pension Insurance). We also implement the Lee-Carter model to explore the trend of mortality rates from both groups and measure the impact of migration on mortality improvement. We found that the mortality improvements and their trends of people moving to and from metropolitan areas behave differently, and we cannot ignore the influence of migration.

Keywords: Longevity Risk, Migration, Mortality Improvement, Lee-Carter Model, Financial Solvency

Section 1: Introduction

Mortality improvement has been a popular research topic in demographic studies since the end of last century. Governments, private sectors, and individuals are all interested in prolonging life expectancy and its impacts. Longevity risk is one of the well-known challenges related to mortality improvement, and the interest in particularly in the reduction of mortality rates and its effect on the life planning after retirement. Seeking the solutions to longevity risk is surprisingly difficult, since it requires knowledge about the application domains (e.g., public and private pension systems), as well as the associated factors. For example, the needs of retirement life can be separated into three categories: financial, health, and living (e.g., long-term care), and the solutions to these needs can be very different.

Zhu et al. (2015) listed three important aspects: mortality slope, time trend and mortality differential, in life insurance mortality studies. There has been abundant literature addressing the mortality slope and time trend. This study focuses on mortality differentials. The ignorance of mortality differentials can result in adverse selection and problems of pricing and liability, which can happen to both social and commercial insurance. Villegas and Haberman (2014) noted that, mortality differentials, and in particular those related to socioeconomic circumstances, pose important challenges for the design of public policies for tackling social inequalities, as well as for the design of pension systems and the management of longevity risk in pension funds and annuity portfolios. Pokorski (1994) pointed out the cause of the failure of the early private life insurance system was due to neglecting insured age and health status which could result in adverse selection. Not only is private life insurance impacted, social security systems also face adverse selection. Beauchamp and Wagner (2013) found that an insured living longer would apply for delayed retirement in order to receive more annuity payments. If the pricing of social insurance does not take individual mortality differentials into consideration, the premium will be underestimated. Hosseini (2015) discovered that the people with higher mortality rates would choose private insurance, afraid of not receiving the corresponding annuity from social security system. In addition to the social security issue, as noted by Coughlan et al. (2011), the successful development of a market of standardized longevity securities requires a good understanding of socio-economic mortality differentials as they are in most situations the main determinant of the basis risk associated with index-based longevity hedges.

As for the mortality characteristics, past studies reveal that mortality rates and indices such as life expectancy usually differ across subpopulations, generally defined by gender, geographic area, or socioeconomic variables and there is a well-recognized inverse relationship between socioeconomic circumstances and mortality, with higher socioeconomic subgroups having lower mortality rates and mostly also experiencing faster mortality improvements than lower socioeconomic subgroups (see, e.g., Shkolnikov et al. 2006; Johnson 2011; Tarkiainen et al. 2012; Raleigh and Kiri 1997). Madrigal et al. (2011) highlighted the relative importance of gender, affluence, lifestyle and retirement health status as predictors for post-retirement mortality, and hence longevity.

In addition to these characteristics, recently, the impact of migration on mortality has drawn more and more attention, which may result from a slowing down of longevity improvements noted at the time of the mass immigration during the early 1990s and an underestimate of mortality improvements in the existing population. Villegas and Haberman (2014) noted that estimating longevity improvements for pension liabilities is problematic in a changing population due to migration. Quite a lot of literature showed that the mortality of existing population improves or deteriorates depending on migrants' heterogeneity for original effects, such as ethnic, geographic, socio-economics, education level, and health care resource (e.g., Bos et al., 2004; Rafnsson et al. 2013; Vandenheede et al., 2012), as well as the effect of adjustment hardships (e.g., Singh and Miller, 2004; Ott et al., 2009). Recently, some literature noted that, migrants exhibit lower mortality rate with their original contributing effects, but their migrant mortality advantage disappears with presence of deteriorating mortality rate over the time (e.g. Harding (2003), Harding (2004), Bos et al. (2007), Vandenheede et al. (2015), Hajat et al. (2010), Lehti et al. (2016), Juárez et al. (2018), Hammar et al. (2002) and Syse et al. (2012)). Nevertheless, the significance of the wear-off in the migrant mortality advantage is still divergent among the literature.

Literature mentioned previously focused on international migration, also known as immigration. However, Skeldon (2017) noted that, international migration studies encountered difficulties in defining international migration both on space and time, resulting in three weaknesses in data: clear destinations and origins of the migration, underestimating the volume of international migration, and the developmental context in which the migration takes place. Contrarily, internal migration tends to be more frequent which makes itself suitable for studying the mobility effect on mortality improvement. Additionally, migrating people probably look for better living standards or medical resources in urbanized areas, which can be more easily observed and measured internally or domestically. Consequently, considerable evidence has been found towards the linkage between the internal migration and mobility (Champion 2001) or urbanization (Champion and Shuttleworth 2016, Bell 2015a, Bell 2015b, Skeldon 2013). Lu (2010) and Nauman et al. (2015) studied the correlation between rural-to-urban migration and health status. By Potts (2013), domestic migration flows can be sensitive indicators of the geography of economic opportunity and vitality.

Nevertheless, to the best of our knowledge, studies into the domestic migration effect on mortality rates are still scarce. O'Reilly et al. (2007), Zimmer et al. (2007), Singh and Siahpush (2014) and Chang et al. (2019) investigated the urban-rural variations in mortality in various countries. This literature mainly focused on current residence area, rather than past migration history, such as the mobility (or migration frequency) or how long the observant stayed in an urban area. In terms of actuarial mortality and liability evaluation, migration itself does not only redistribute the demographic profiles of each sub-area but also lead to mortality improvement or deterioration of the overall population, providing that migration behaviors imply some special health or economic related issues, such as better livelihood, mobility, urbanization and better medical resources. To fulfill this gap, this paper considers the influence of domestic migration behavior (in terms of migration frequency and urban staying duration) on mortality, based on a public pension scheme in Taiwan.

Taiwan's public pension plan, National Pension Insurance (NPI), is experiencing a decreasing premium payment ratio, implying financial problems and even its sustainability. The premium payment ratio usually is connected with demographic factors, such as age, gender, economic status, and urbanization levels. In particular, we also observed that mortality improvement and its trend are very different from the NPI data, not restricting to the premium payment ratio. For example, the mortality difference among residence areas may be related to health resources and income gaps due to the urbanization. Hence, migration between urban and suburban (or rural) areas would probably affect the future mortality trend and the potential pension liability.

In performing actuarial assessments, it is worthy to include further observation on the mortality rates (or actuarial liability) with respect to these demographic and socioeconomic variables, the premium payment behavior and migration. In view of this, there is a need for mortality models to capture the characteristics of mortality profile, such as mortality trend, slope, and differential (Zhu et al., 2015). Of course, we expect that the performance of mortality models is usually data-dependent. For example, Madrigal et al. (2011) constructed a multivariable model for pensioner baseline mortality to discuss the impact of a healthy lifestyle or affluence attenuates with age. The mortality differentials can also result in adverse selection.

This study mainly aims to verify the impact of these factors on mortality differentials from NPI data during the period of 2009-2017. Exploratory data analysis indicates that the changing profile (such as migration between urban and suburban or rural areas as well as low-income or disability) of NPI participants is associated with lower premium payment willingness, and possibly result in mortality differentials. Empirical evidence of this study shows that mortality improvement or differential is actually associated with migration behaviors. We will also examine the influences of socioeconomic variables on mortality improvement. Our empirical result can lead to several policy implications such as reallocating more premium subsidy according to mortality difference and corresponding annuity cost, as well as the anti-selection effect in suburban areas with lower annuity costs and lower willingness in paying premium as mentioned in Hosseini (2015).

The remainder of this study is organized as follows. Section 2 presents the basic description of Taiwan's National Pension Insurance and the data used in this study. Section 3 shows the results of exploratory data analysis for the National Pension Insurance data, followed by numerical analysis in Section 4. Finally, Section 5 presents concluding remarks and policy implications.

Section 2: Taiwan's National Pension Insurance

Taiwan's National Pension Insurance, or NPI, was launched in 2008, under the supervision of the Ministry of Health and Welfare. The NPI is designed for citizens who are not enrolled in other social insurance. The goal of the NPI is to provide monthly payments to insured citizens (participants) for life after they reach age 65, and the coverage also includes payments for maternity, death, and disability under age 65. The NPI is a defined benefit plan and is financed on the subsidy from the Taiwan government, as well as premiums from the insureds. Usually, the government and the insured pay 40% and 60% of the premium, respectively. However, the low-income or disabled members receive a higher subsidy from the government and some of them don't need to pay premium.

The NPI is part of Taiwan's public pension system and is designed as a supplementary plan for people not covered in other pension plans, such as labor insurance, civil servant insurance, military servant insurance, and farmer insurance. In particular, the target population of the NPI are citizens not employed and without any social insurance coverage for a pension, such as housewives and part-time workers. In general, Taiwan citizens, who are age 25 to 64, are eligible for the NPI, need to pay monthly premiums before reaching 65 years old. However, the participants of the NPI can lapse (or suspend) temporarily if they are qualified for any other pension plans. During the participation period, the credited contribution for pension income of a participant is credited fractionally on a monthly basis, providing each monthly premium payment.

The premium is a single rate, in terms of payroll rate as a certain percentage of the salary level. However, it is not guaranteed and can be adjusted based on the bi-annual actuarial reports. The 2017 premium rate is 8.5% and is scheduled to increase 0.5% every two years in the future, providing the fund is expected to exhaust in 20 years. According to the actuarial reports, the funded assets relative to the total actuarial liabilities (funding ratio) is decreasing dramatically from 46.1% to 27.0% in the time period 2009-2017. It is believed that the prolonging life expectancy (or mortality improvement) and low interest/return rate are the two major causes of lower NPI assets. This financial distress of the NPI and other social insurance systems receive a lot of public attention and intense worry about the sustainability of the entire social security system in Taiwan.

The sustainability is not the only challenge that the NPI needs to deal with as the decreasing participating rate is another major concern. Although the goal of the NPI is to provide basic pension protection, many eligible citizens choose not to pay the monthly premiums. Slower economic growth is one of the main reasons for the decreasing participating rates. The NPI was originally scheduled to launch before 2000 but the Jiji's earthquake in 1999 disrupted Taiwan's plan[1]. The average annual growth of Taiwan's GDP was more than 18% in 1970's & 80's, reducing to around 7% between 1990-2000, and further shrank to 2~3% after 2000. (Source: Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Taiwan, R.O.C.) As a result, the salary of the average Taiwan citizen has remained almost the same for the last 20 years and people are reluctant to join the new public pension plan.

[1] The Jiji earthquake, also known as the 921 earthquake, was the second-deadliest quake in Taiwan's history. It occurred on September 21, 1999, causing 2,415 deaths and NT$300 billion (US$10 billion) worth of damage.

In addition to the slow growing economics, the interest rate and return of investment have also dropped dramatically. However, Taiwan's social and commercial insurance used a very optimistic assumption in the investment return rate. For example, the interest rate of commercial insurance products was around 6% and some even surpassed 7% before 2000. This creates profit loss and heavy burden to the insurance companies. Social insurance also suffers from the assumption of high investment return rates and it is believed that some public pension plans (e.g., labor insurance) will go bankrupt in a few years. A lot of people have lost faith in public pension plans and thus are not willing to take part in the NPI.

The main goal of NPI is to provide economically or physically vulnerable people with annuities for their lives at older ages. However, those vulnerable people generally are not able to afford the premiums. Even though the Taiwan government subsidizes their premium at least 40% up to 70%, the overall premium payment rate still decreases from 50.9% to 47.4% ever since 2008. Participants' low premium payment willingness will deteriorate the financial sustainability of the NPI and has awakened the government's concern. Accordingly, it would be helpful to explore why people choose not to pay the premium. Therefore, this study presents the mortality difference in terms of demographics such as age, gender and living area, economical and physical status, and premium payment behavior, as well as the relationships of these factors among the NPI participants.

Table 1

SUMMARY STATISTICS FOR THE NPI DATA (2009-2017)

Year	Active Insureds				Lapse Insureds (5)	Total Participants (6)=(4)+(5)
	PPR=0% (1)	0%<PPR<100% (2)	PPR=100% (3)	Total (4)=(1)+(2)+(3)		
2009	1,075,980 (26%)	218,400 (5%)	2,797,805 (68%)	4,092,185 (88%)	578,351 (12%)	4,670,536 (100%)
2010	1,051,967 (27%)	453,277 (12%)	2,431,421 (62%)	3,936,665 (72%)	1,553,096 (28%)	5,489,761 (100%)
2011	1,032,451 (27%)	511,159 (14%)	2,238,059 (59%)	3,781,669 (62%)	2,324,932 (38%)	6,106,601 (100%)
2012	1,014,185 (28%)	563,386 (15%)	2,067,114 (57%)	3,644,685 (55%)	2,959,761 (45%)	6,604,446 (100%)
2013	1,024,297 (29%)	625,652 (18%)	1,922,140 (54%)	3,572,089 (50%)	3,520,923 (50%)	7,093,012 (100%)
2014	1,036,281 (29%)	679,346 (19%)	1,802,911 (51%)	3,518,538 (47%)	4,030,738 (53%)	7,549,276 (100%)
2015	1,038,530 (30%)	728,742 (21%)	1,662,613 (48%)	3,429,885 (43%)	4,533,225 (57%)	7,963,110 (100%)
2016	1,045,315 (31%)	786,666 (23%)	1,524,819 (45%)	3,356,800 (40%)	5,002,319 (60%)	8,359,119 (100%)
2017	1,052,189 (32%)	874,085 (27%)	1,347,190 (41%)	3,273,464 (38%)	5,446,094 (62%)	8,719,558 (100%)

Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Section 3: Exploratory Data Analysis for the NPI Data

First, we should use the NPI data, collected by Bureau of Labor Insurance (BLI) during 2009 and 2017, to explore the participating rates in recent years. Table 1 shows the summary statistics of NPI data, including the numbers of active and lapse insured, representing the currently insured or ever-insured status, respectively. The number of participants increases every year and it is more than 1/3 of Taiwan population since 2014. However, the numbers of active participants stop growing from 2012, leading to decreasing premium income. The numbers of lapse participants surpass those of active participants since 2014, and the participant rate drops to 37.5% in 2018, or only about 1/3 participant paying premium on time.

Table 2
DEMOGRAPHIC STATISTICS FOR THE NPI DATA (2009-2017)

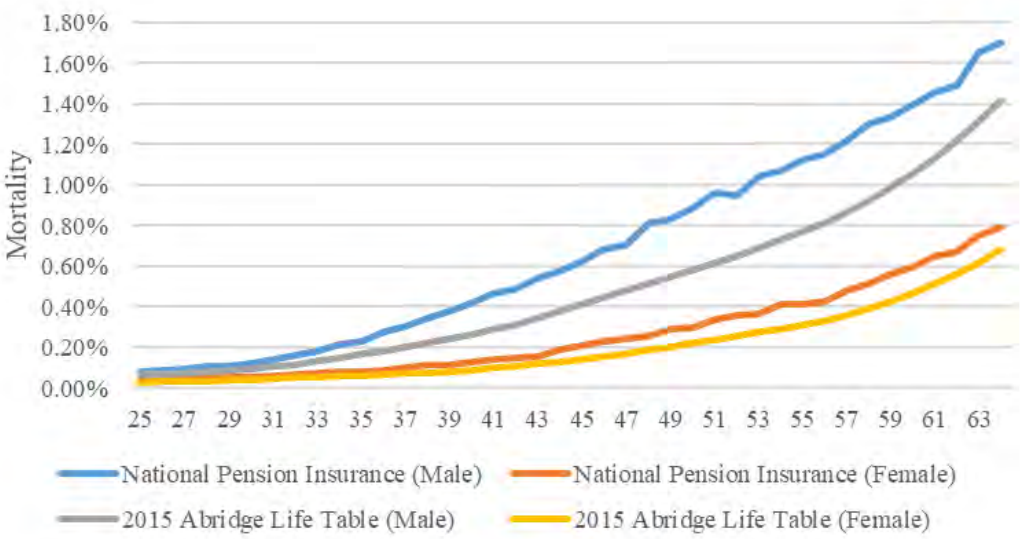
Year	Age	Gender		Area				Weak		Premium Payment Ratio
		Male	Female	Northern	Center	South	East	Vulnerable	Non-Vulnerable	
2009	43	47.9%	52.1%	47.0%	23.4%	26.7%	2.8%	6.9%	93.1%	50.9%
2010	43	48.5%	51.5%	47.2%	23.4%	26.5%	2.9%	7.0%	93.0%	50.0%
2011	43	48.7%	51.3%	47.4%	23.4%	26.3%	2.8%	6.9%	93.1%	49.6%
2012	43	48.8%	51.2%	47.6%	23.4%	26.2%	2.8%	6.8%	93.2%	49.2%
2013	43	48.8%	51.2%	47.7%	23.4%	26.1%	2.8%	6.5%	93.5%	48.7%
2014	44	48.8%	51.2%	47.7%	23.4%	26.0%	2.8%	6.4%	93.6%	48.1%
2015	44	48.8%	51.2%	47.8%	23.4%	26.0%	2.8%	6.2%	93.8%	47.5%
2016	44	48.8%	51.2%	47.8%	23.5%	26.0%	2.8%	6.2%	93.8%	47.2%
2017	45	48.8%	51.2%	47.8%	23.5%	25.9%	2.8%	6.0%	94.0%	47.4%

Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

We can use the premium payment ratio (PPR), i.e., the actual premium paid vs. the total payable premium (during participation period), to examine the financial status of the NPI. From Table 2, we can see that the PPR is close to 50%, much higher than the proportion of active participants in Table 1. Table 2 also illustrates the other important factors or variables in this study, including age, gender, residential areas, vulnerable (low-income or disability) and premium payment ratios. Accordingly, the proportions of male insureds are slightly lower than those of female insureds. This is an expected result since a fairly large proportion of the NPI participants are housewives. The average age is between 44 and 45 years old, increasing slightly due to fewer new entrants. Regarding the distribution of residential areas, most of the NPI insureds are in the northern area, close to Taiwan's capital Taipei. The proportion of vulnerable groups of the NPI decreases annually.

From Tables 1 and 2, we can see that the profile of NPI participants (including insured and lapsed) change drastically, with lower PPR and more lapsed participants. It would be interesting to check if there is biased selection, i.e., the actual mortality rates differing significantly to the projection, and thus jeopardize the entire NPI. Note that the proportions of NPI participants in the Northern and Central areas have a slight increase, which may imply domestic migrations between areas. Therefore, it may be worthy of having further exploration on the mortality rates with respect to these demographic and socioeconomic variables and evaluate their relationship with the premium payment behavior.

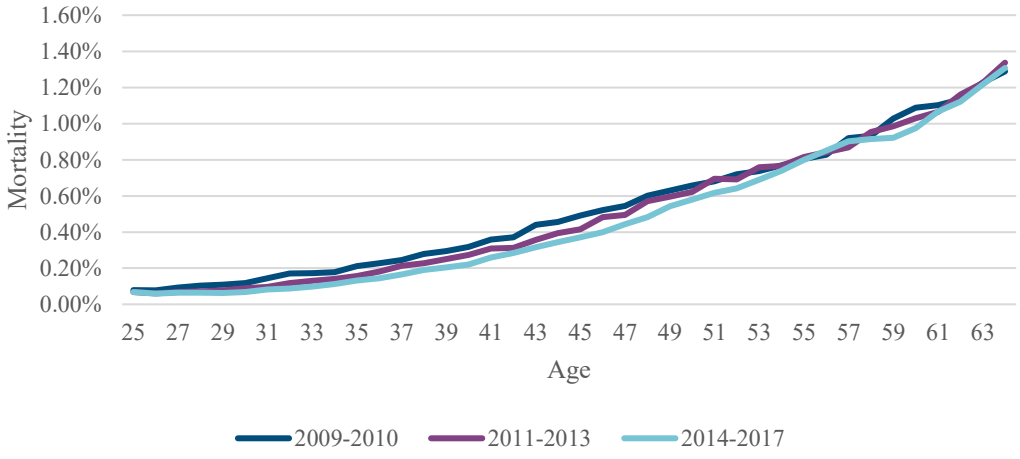
Figure 1
MORTALITY RATES OF NPI (2009-2017) AND TAIWAN POPULATION (2015)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

We should inspect the mortality rates of NPI data with respect to different demographic attributes. Figure 1 are the average NPI mortality rates in 2009-2017 for the male and female, comparing them to those of Taiwan population in 2015. The NPI mortality rates are obviously higher than those of Taiwan population, indicating that the NPI can be treated as a form of substandard insurance. The mortality differences between the NPI and Taiwan populations increase with age and are larger for the male. The trend of NPI mortality rates is also significantly different to that of Taiwan's population. Figure 2 shows the trend of NPI mortality rates (both sexes combined) in the format of 3-year average and there are no mortality improvements beyond age 55. The age-wise reduction rates of Taiwan's mortality improvement are about 1~2% (Yue and Huang, 2011), much higher than those of NPI data.

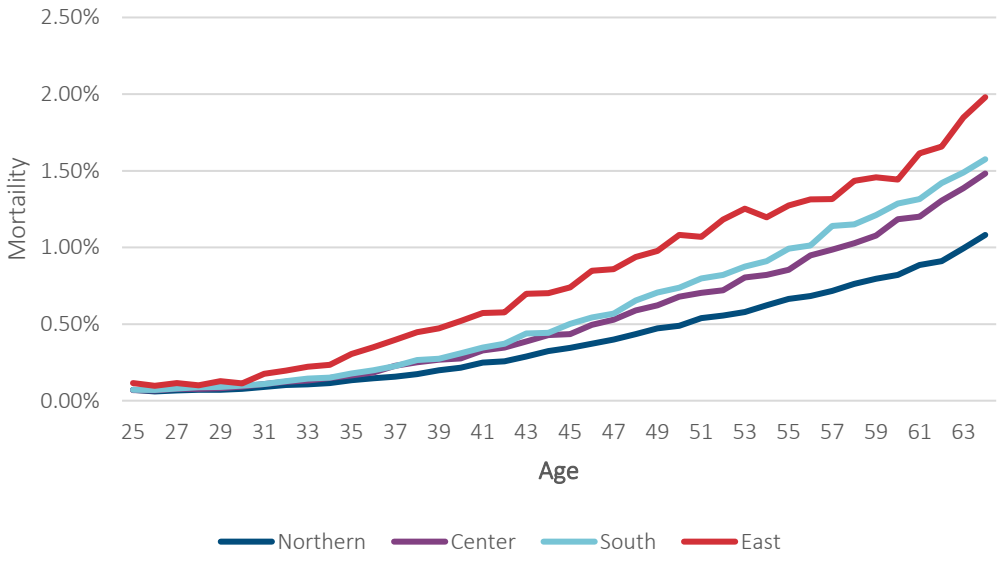
Figure 2
TREND OF NPI MORTALITY RATES (3-YEAR AVERAGE)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

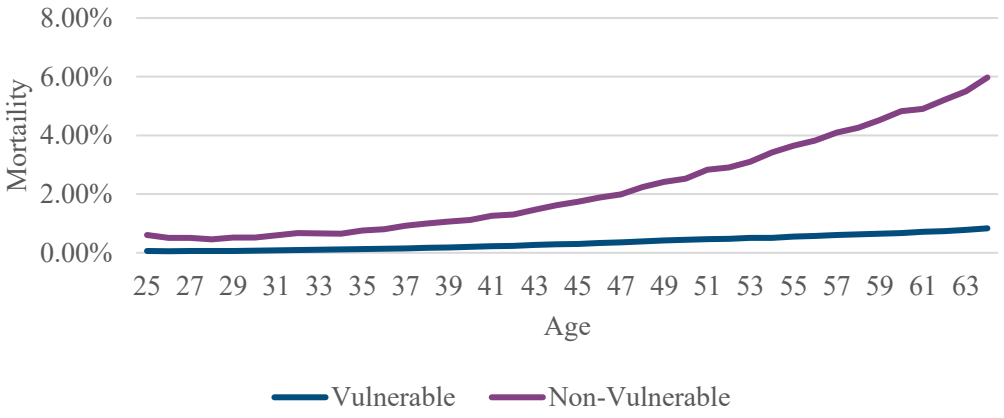
Next, in Figure 3, we evaluate the mortality differential with respect to residential areas, dividing Taiwan into four areas: Northern, Central, Southern and Eastern. Specially, we do not include the remote islands since their populations are too small and would create large mortality fluctuations. Generally speaking, the NPI participants in the northern area have the lowest mortality rates, following by those of central and southern Taiwan, and those in the eastern area have the highest mortality rates. The results of mortality rates are consistent with the urbanization level and medical resources, where people in the northern Taiwan enjoy the best overall resources. The NPI mortality rates with respect to residential areas are also consistent with those of county-wise mortality rates in Taiwan.

Figure 3
MORTALITY DIFFERENTIAL W.R.T. RESIDENTIAL AREAS (2009-2017)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

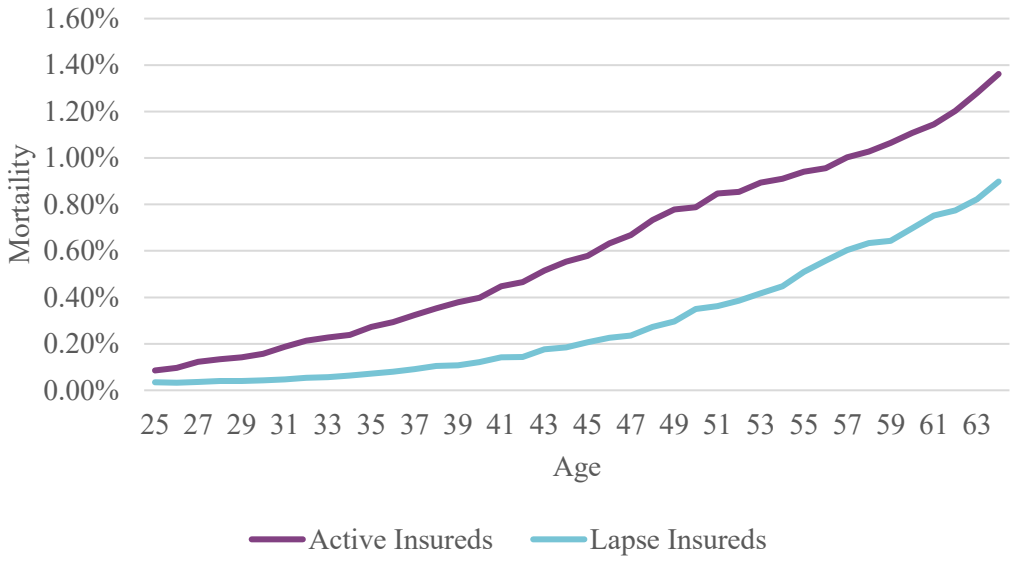
Figure 4
MORTALITY RATES OF VULNERABLE AND NON-VULNERABLE GROUPS (2009-2017)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

The NPI mortality rates also vary a lot for different attributes such as vulnerable group, and the mortality rates of vulnerable groups are higher than those of other insured (Figure 4), implying an association between mortality rates and income levels, or "vulnerable" is a good indicator for sub-standard group. The employment status is also a significant risk factor of NPI mortality rates. We evaluate the mortality differential of employment status, in terms of active and lapsed in NPI (Figure 5). Note that the active NPI and lapsed NPI insureds are associated with the unemployed and employed statuses, respectively. Apparently, the mortality rates of active insureds are higher than those of lapsed insureds. The high mortality rates of active insureds are expected, since usually they are unemployed and possibly with lower income and less health care resources. The lapsed insureds can be people who are temporarily unemployed and will probably work again (i.e., leaving the NPI).

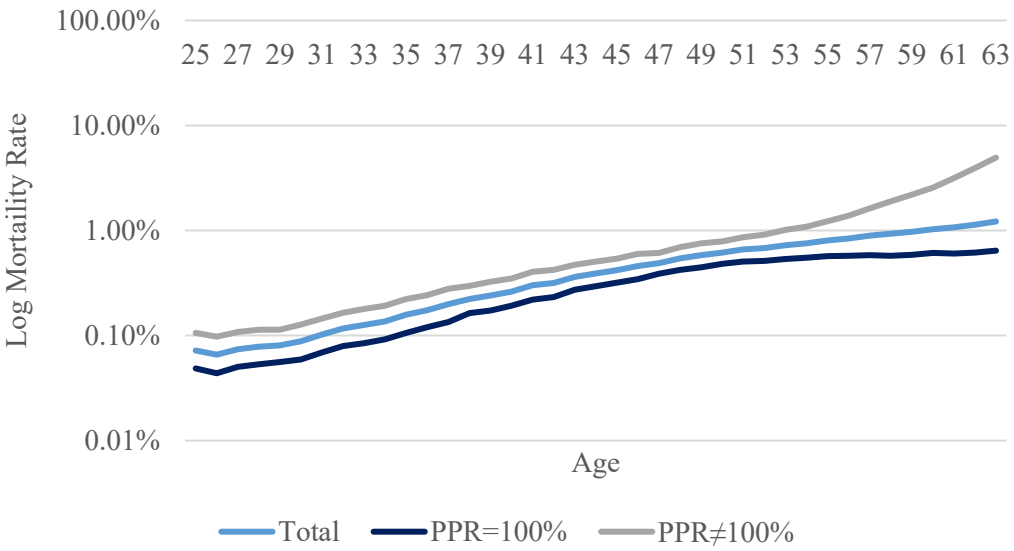
Figure 5
MORTALITY RATES OF ACTIVE AND LAPSED INSUREDS (2009-2017)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

The percentage of PPR is also connected to the mortality rate. Figure 6 shows that the people with higher mortality rates generally tend to evade the premium payment, which is consistent with the result in Hosseini (2015). That is, people with higher mortality rates would choose private insurance, afraid of not receiving the corresponding annuity from the social security system. This can be used to explain why the NPI has lower premium payment rates, since the NPI participants have higher mortality rates. Maybe Taiwan's government can consider the option of returning premium for those NPI participants, if they receive less annuity payment than their paid premium.

Figure 6
MORTALITY RATES W.R.T. PREMIUM PAYMENT RATIO (2009-2017)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

According to the results of preceding exploratory data analysis, mortality differences do exist among characteristics (e.g., residential areas and employment status). While the population profile among those categories of characteristics varies, the future mortality (improvement) trend will be different from merely past experienced. For example, the mortality difference among residence areas may be related to health resources and income gaps due to the urbanization. Hence, migration between urban and suburban areas would probably affect the future mortality trend and the potential pension liability. Furthermore, premium payment behavior may reflect insureds' personal wealth condition or the demand of NPI, and highly contributed to the future pension obligation of the NPI fund. While more and more wealthy people join NPI, which is really observed by the end of 10-year grace period[2], the future pension benefit would increase accordingly. Hence, an empirical review of how recent improvements have differed by longevity characteristic, and how their future evolution may be modelled, is necessary and will be discussed later in this study.

[2] NPI allows participants (or insureds) to pay their premium arrears within 10-year grace period since the starting year 2008. Those unpaid premiums will not be accredited to pension benefit.

Section 4: Domestic Migration and Numerical Analysis

Migration is a dynamic process and it contains important and sometimes critical information. We expect that the NPI participants generally are those with fewer incomes or assets (i.e., vulnerable group), and moving would be a costly task to them. In other words, the rates of domestic and international migration would be smaller for the NPI participants. We should verify this in this section. Also, assuming that the NPI participants are vulnerable groups, it would be interesting to check the mortality rates of moving participants. According to the migration theory, there are two driving factors: push or pull effects (Zimmermann, 1996). For example, if the participants moving away have higher/lower mortality rates, then the push/pull factor can be the cause. For this study, we think that the NPI participants are with less resource and less likely to move. If they move, then their mortality rates are likely to be higher than those who don't move. We should verify these ideas in the section.

We will use the addresses registered for all NPI participants to decide whether they move, and the addresses are updated providing that they are active (not lapsed). There are advantages and disadvantages for using the registered addresses to define migration. Locating where people live is not easy and it becomes more difficult nowadays. Using the address would be more efficient. However, we cannot trace the complete moving profile, such as the exact moving time and location, and people do not necessarily stay at the address registered. Moreover, the address record will be missed when participant lapses and the moving time is right-truncated due to the 10-year observation period for the NPI data. The NPI only records the addresses of active participants and thus those with missing addresses will not be considered in this study. This means that the sample bias may exist since the lapsed participants are not included. Therefore, it is very difficult to profile the dynamic migration and its influence on mortality rates.

For this purpose, we select the most urbanized and populous area, the Northern Taiwan, as the benchmark for exploring the relation of migration and mortality. The Northern Taiwan has the most abundant resources (e.g., job opportunity and health care) and thus the residents in the Northern Taiwan have the lowest mortality rates, including the NPI participants (Figure 5). This indicates that the Northern Taiwan has a pull force attracting people from other regions in Taiwan. To simplify the calculation, we consider the two-region migration, between Northern and non-Northern Taiwan. Therefore, the NPI participants will be divided into three groups: staying in Northern Taiwan (N), staying in non-Northern Taiwan ($\overline{N}$),migration (M) including moving to and from Northern Taiwan.

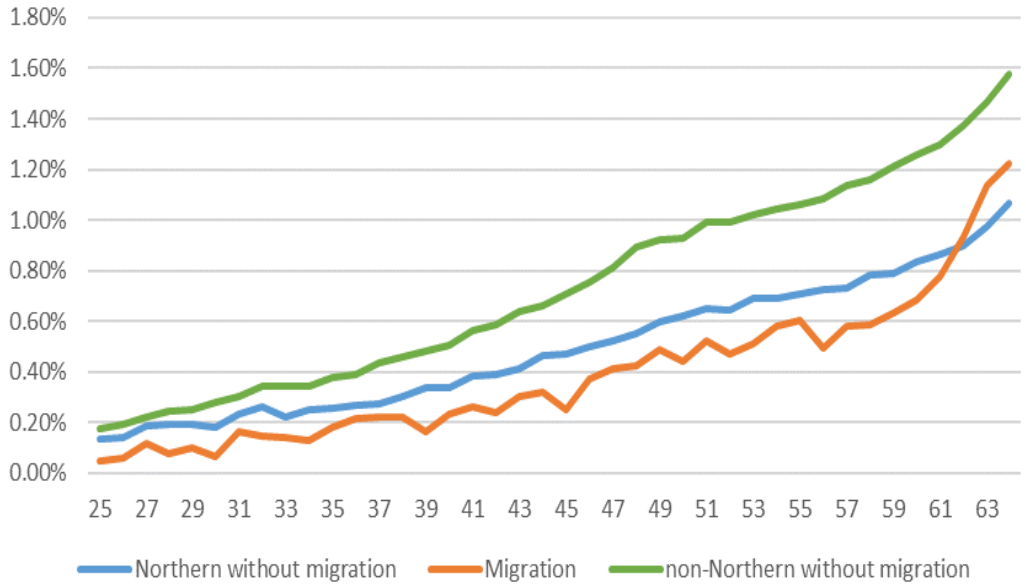
Table 3
SUMMARY STATISTICS FOR MIGRATING AND NON-MIGRATING GROUPS

	Staying Northern (1)	Migration (2)	Staying non-Northern (3)	Total (4)=(1)+(2)+(3)
# of people	1,747,466	138,299	3,958,113	5,843,878
Exposure	7,067,317	940,720	15,782,655	23,790,692
Deaths	41,578	4,092	131,312	176,982

Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Table 3 shows the summary statistics of the three groups of participants. As expected, the migration rate of NPI participants is smaller, which is around 2.4%, comparing to the domestic migration rate 5% in Taiwan. Also, the sex ratios of migration and non-migration groups are very different, and the migration group has higher female ratios (Figure A-1 in Appendix A). On the other hand, the average ages are higher for the non-migration group, but the migration group is catching up, surpassing non-migration group in 2017 (Figure A-2). The proportion of vulnerable people are higher for the migration group and it seems that the vulnerable people are less likely to move (Figure A-3), as mentioned earlier. Also, the group staying in the Northern Taiwan has the Premium Payment Ratio in all groups (Figure A-4).

Figure 7
MORTALITY RATES OF MIGRATION AND NON-MIGRATION GROUPS (2009-2017)

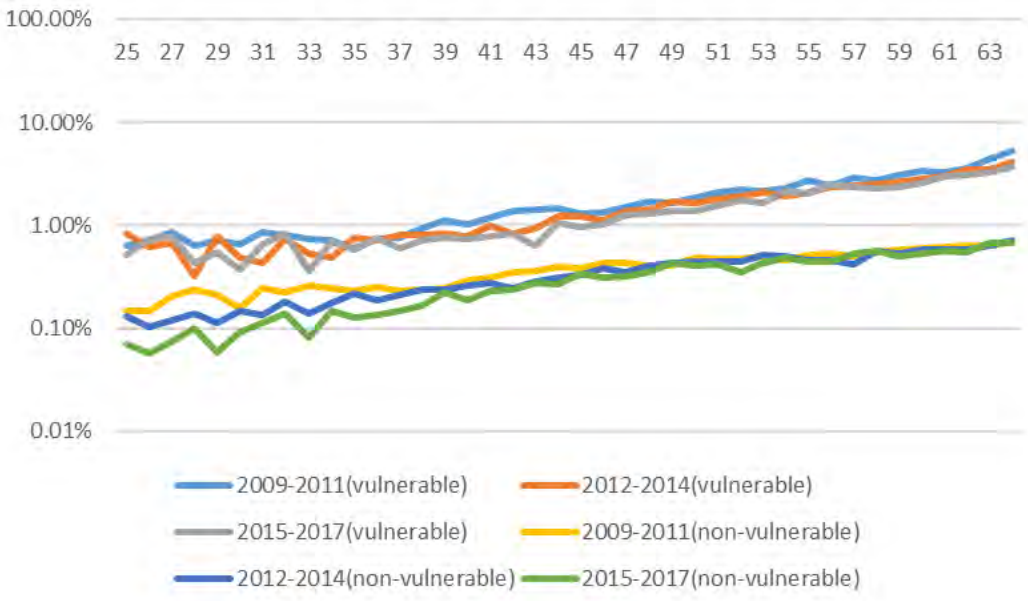


Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Next, we examine the mortality rates for different groups of NPI participants. Figure 7 exhibits the average mortality rates during 2008/10 to 2017/09 for the three groups in Table 3. Since the numbers of moving participants are not many, we combine the numbers of moving to and moving from Northern Taiwan into migration group. For the average mortality rates in 2008-2017, the group staying in non-Northern Taiwan ($\overline{N}$) has the highest mortality rates while the migration group has the lowest mortality rates. This seemly contradicts our expectation. However, the mortality rates of the last three years (2015-2017) tell a different story, the group staying in the Northern Taiwan has the lowest mortality rates.

To further examine the mortality rates, for each of three groups of NPI participants, we compare the mortality rates at different time periods. Again, we adapt the 3-year format and compute the mortality rates of 2009-2011, 2012-2014, and 2015-2017. The mortality rates of three 3-year periods are in Appendix B. The mortality rates of non-migration groups (N and $\overline{N}$) gradually decrease and the mortality improvement is quite apparent (Figures B-1 and B-2). On the other hand, the mortality rates of migration group (M) are the lowest in 2009-2011 and they deteriorate with time (Figure B-3).

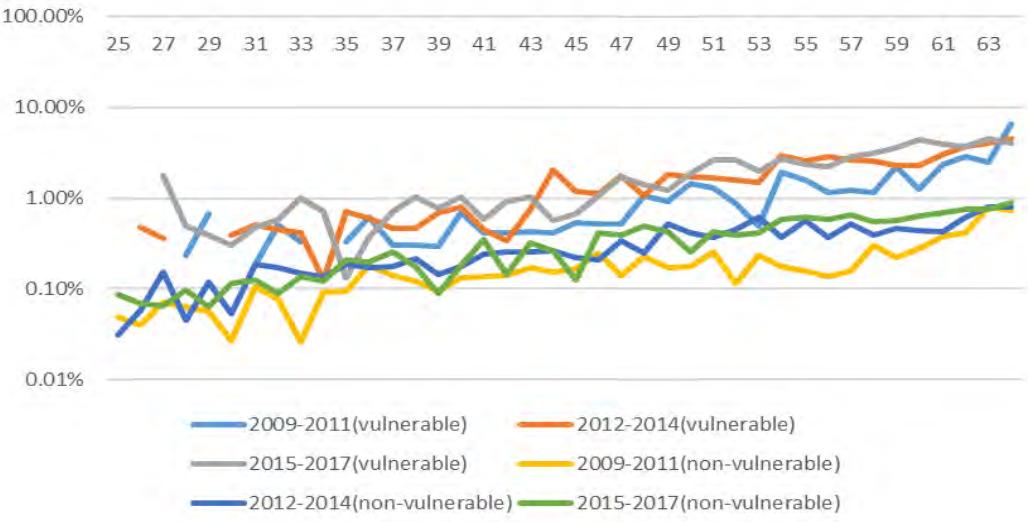
Figure 8
MORTALITY RATES OF PARTICIPANTS STAYING IN NORTHERN TAIWAN (VULNERABLE STATUS)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

We further separate the participants into vulnerable and non-vulnerable people. We use the group staying in Northern Taiwan and migration group as a demonstration (Figures 8 and 9). The vulnerable participants have higher mortality rates for both groups, and the difference of mortality rates between vulnerable and non-vulnerable participants are larger for the group staying in Northern Taiwan. Also, for both vulnerable and non-vulnerable participants, the group staying in Northern Taiwan does experience mortality improvement, but the migration group suffers from increasing mortality.

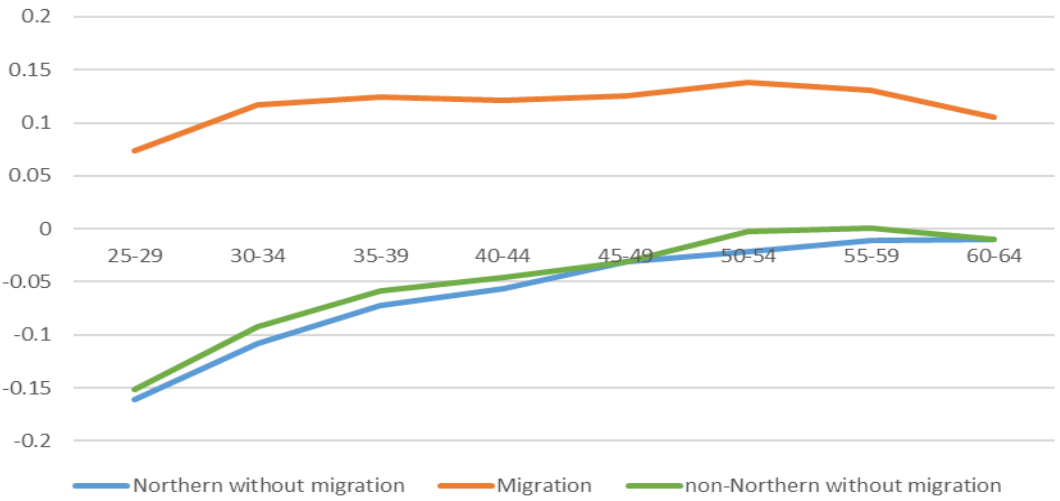
Figure 9
MORTALITY RATES OF PARTICIPANTS IN MIGRATION GROUP (VULNERABLE STATUS)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

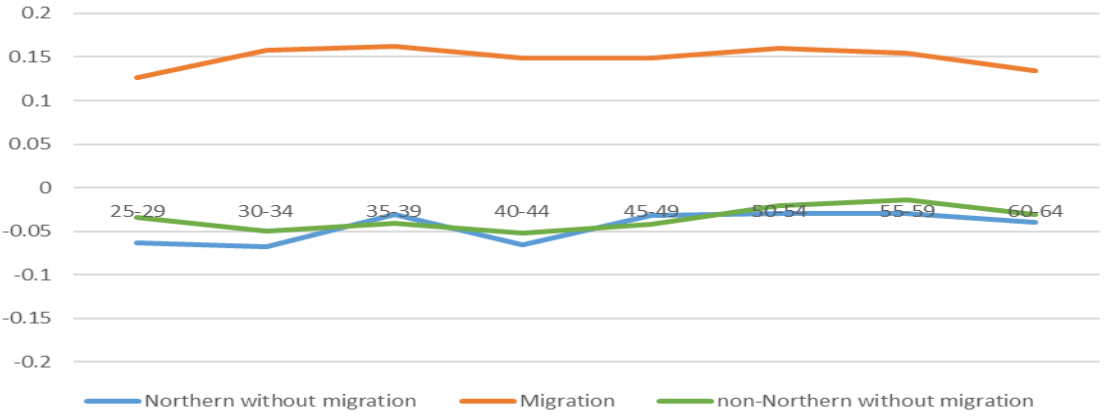
Since the mortality rates have obvious time trend, we should use the Lee-Carter model to measure the mortality improvement. To avoid the fluctuations of the parameters' estimates in the small sample case, the mortality rates are computed in the format of 5-age group, with the help of Kernel graduation (Silverman, 1984). We can look at the term $\beta_x \cdot \kappa_t$ directly, which is the mortality improvement at age x. Incidentally, the time parameter κ_t can be estimate via time series function, or simply assumed to be a linear function of time. The mortality rates of vulnerable and non-vulnerable participants behave differently and thus we separate them into two Lee-Carter models.

Figure 10
MORTALITY IMPROVEMENT $\beta_x \cdot \kappa_t$ OF THREE NON-VULNERABLE GROUPS



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Figure 11
MORTALITY IMPROVEMENT $\beta_x \cdot \kappa_t$ OF THREE VULNERABLE GROUPS



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

The mortality improvements of non-vulnerable participants for three migration and non-migration groups are in Figure 10. The mortality rates of migration group have about the same annual increment at all ages, while those of the non-migration groups decrease and the largest decrement is at younger ages. The mortality improvements of vulnerable participants for three migration and non-migration groups are follow a similar pattern, but the mortality decrements of non-migration groups are fairly uniform (Figure 11).

Section 5: Conclusions and Discussion

Mortality models are frequently used to deal with the challenges of mortality improvement and longevity risk. The study of mortality models often targets aspects such as mortality trend, slope, and differential (Zhu et al., 2015). The mortality trend and slope are usually the focus. while the goal of this study is on the mortality differential. Specially, in addition to demographic factors, such as age, gender and residence area, we are interested in the impact of migration on mortality differentials. One of the motivations is that ignoring the factors attributing to mortality differential among the insureds is likely to make false judgement on mortality trend and adverse selection, and thus jeopardize actuarial valuation and even financial solvency of public insurance.

In this study, we analyzed the data from Taiwan's National Pension Insurance (2009-2017), a public pension plan in Taiwan. We found that mortality differential is associated with migration. In particular, the migrating participants have lower mortality rates but suffer from deteriorating mortality, while the non-migrating participants experience mortality improvement. We are not sure about the exact causes and the increasing proportion of vulnerable participants among the migration group could be one of them. However, this cannot explain why both the vulnerable and non-vulnerable participants of the migration group suffer from deteriorating mortality (Figures 10 and 11). Interestingly, the vulnerable and non-vulnerable participants of non-migration groups present mortality improvement. Empirical evidence in this study shows that, domestic migration in Taiwan does result in mortality improvement, which is associated with its implicit demographic characteristics: more female, younger, less vulnerable. Notably, different magnitude in mortality improvement are exhibited between vulnerable and non-vulnerable participants (by Figures 10 and 11), which indicates the right level of premium subsidy should be considered by government. For this purpose, a more scrutinized analysis is required to compare the mortality difference between vulnerable and non-vulnerable participants under various combinations of demographic variables, such as age, gender and even migrating frequency and staying duration in urbanized area of this study.

Selection effect is another possibility of deteriorating mortality in the migration group. In other words, the participants are healthier at the time of migration, but they become weaker with time after the migration. This situation can happen, for example, when the participants have serious illness and they move to places with better medical facilities. If we can obtain the reasons of migration, then we may explore the causes of deteriorating mortality (e.g., if people are forced to migrate) and other phenomena from the NPI data, such as negative correlation between the proportion of vulnerable participants and premium payment ratios. Unfortunately, the NPI did not provide this kind of information.

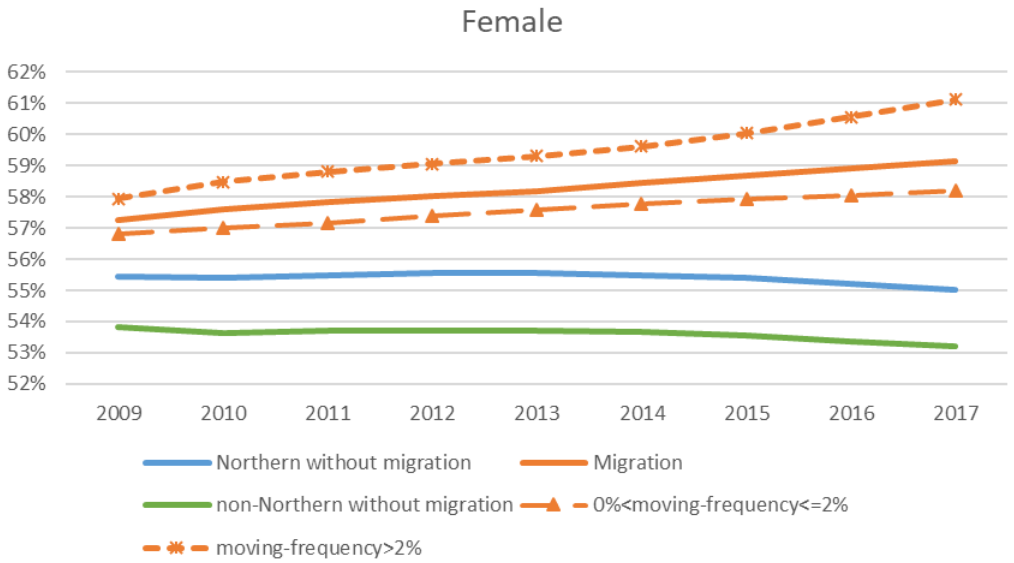
Also, the premium payment ratio (PPR) of NPI has been fallen right from its starting date and it is below 50%. This will definitely threaten the sustainability of this social insurance program. We think there are at least two possibilities of decreasing PPR. First, the NPI participants have shorter life expectancy and maybe they are afraid of not having their money back at the time of death. We suggest that the Taiwan government adapt the idea of "Return-of-premium" and guarantee the total annuity received is no less than their premium paid. The other possibility is that some participants are not qualified to be in the vulnerable group, but they cannot afford the premium. In this case, the government needs to figure out some sort of subsidy programs which help these vulnerable people.

Moreover, the reluctance of premium payment has endangered the sustainability of NPI. Collins-Sowah et al (2013) addressed that some people may prefer community or family support for their elder life to public pension scheme. Instead, migration people may not reside in some community or family. Comparing to non-migration people, migration people are more affordable but reluctant to premium payment, but live long implying actuarial liability, according to our empirical finding. We suggest the Taiwan Government consider a defined contributed micro pension scheme, namely MPS, proposed by Collins-Sowah et al (2013) with early withdraws to hedge longevity risk for those migrants.

Regarding mortality projection, although the size of the migration population is not likely to dominate the future demographic profile, the deteriorating mortality of the migration group is expected to slow down mortality improvement, especially for the suburban (Non-Northern areas) where immigrants outnumber emigrants in recent years. Consequently, there will be more and more people with lower mortality rate moving into the suburban (Non-Northern), comparing to the urban (the Northern). Since that, the demographic difference in mortality and actuarial liability associated with annuity cost between the urban (the Northern) and the suburban (Non-Northern) areas will enlarge as long as migration goes on. Empirical results show that the premium payment rates among the insureds of Northern, Central, Southern and Eastern areas also follow a similar order, which are 29.9%, 13.2%, 14.3% and 1.5%, respectively. Accordingly, the suburban areas with lower annuity costs (such as Southern Taiwan) suffer unwillingness to pay premium, which may indicate the anti-selection noted by Hosseini (2015). We suggest that the government implements premium subsidy for the vulnerable people in the suburban areas, in order to stimulate the willingness of paying premium. Notably, although the migration population only takes about 2% to 3% of all NPI participants, recently increasing migrating tendency in Taiwan would probably not just redistribute demographic characteristics but also result in mortality improvement, which implies a more or less impact on actuarial liability of NPI and accordingly a more complicated actuarial model would be needed for the mortality projection and demographic evolution.

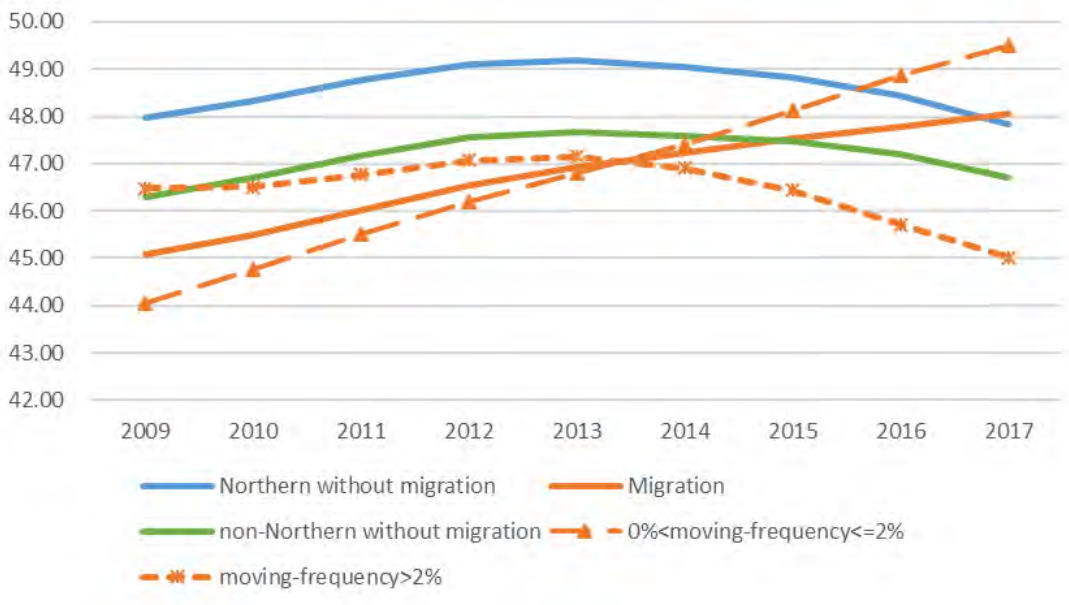
Appendix A: Mortality Trend of Three Groups of NPI Participants

Figure A-1
FEMALE RATIOS OF MIGRATION & NON-MIGRATION GROUPS



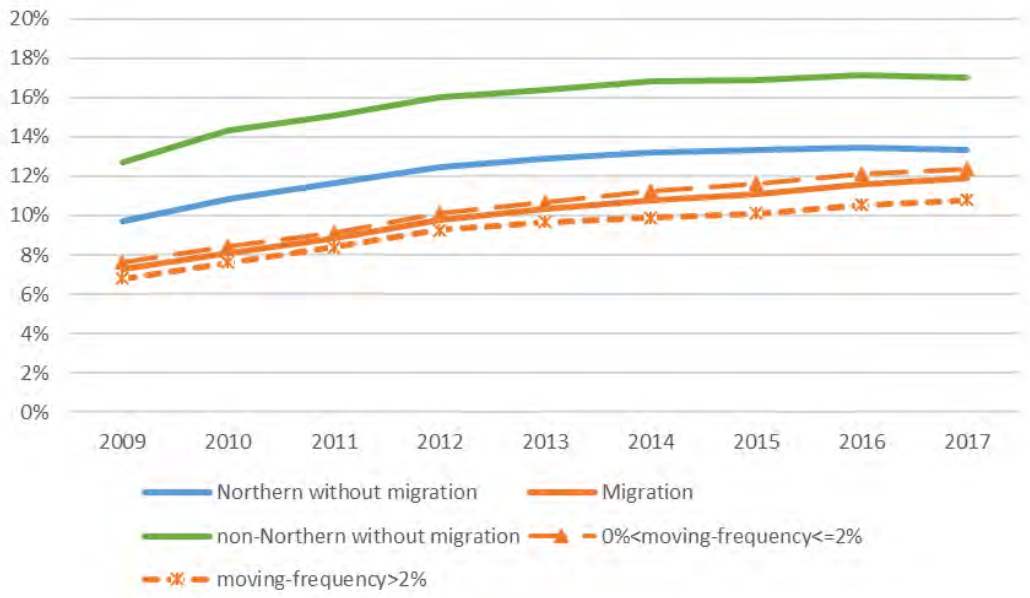
Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Figure A-2
AVERAGE AGES OF MIGRATION & NON-MIGRATION GROUPS



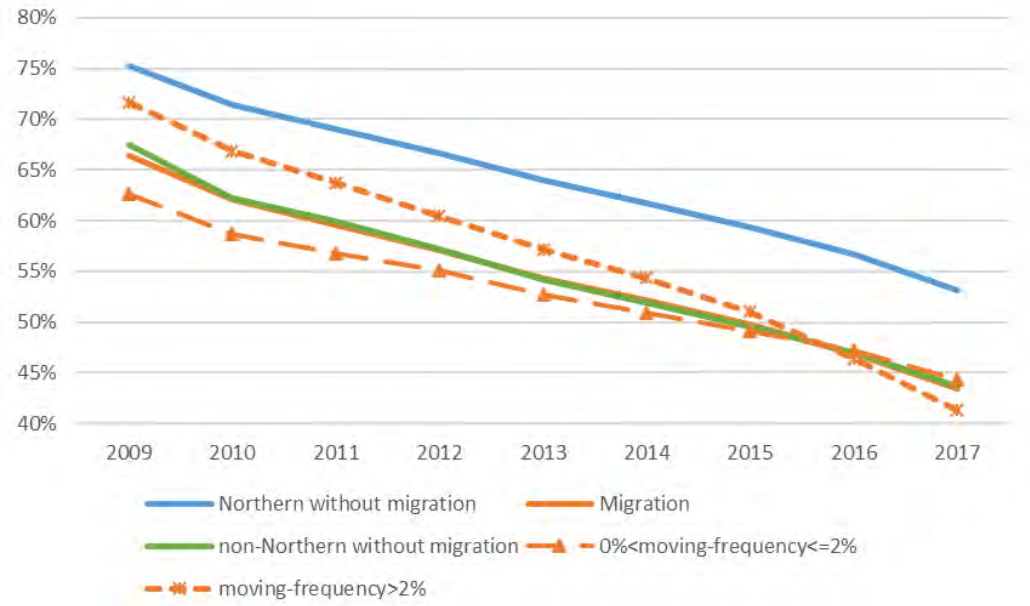
Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Figure A-3
VULNERABLE PROPORTIONS OF MIGRATION AND NON-MIGRATION GROUPS



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

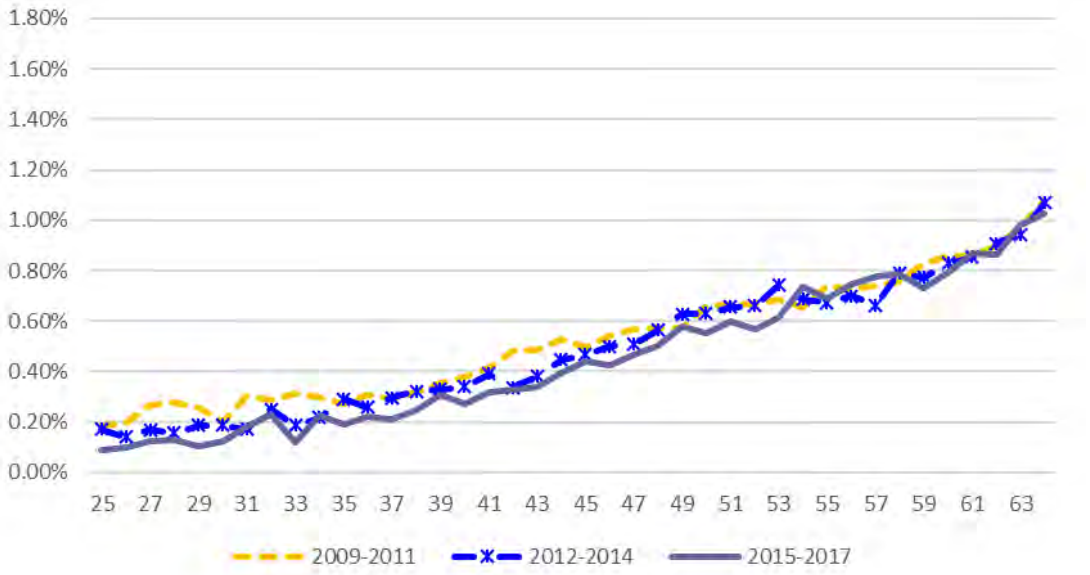
Figure A-4
PREMIUM PAYMENT RATIO OF MIGRATION AND NON-MIGRATION GROUPS



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

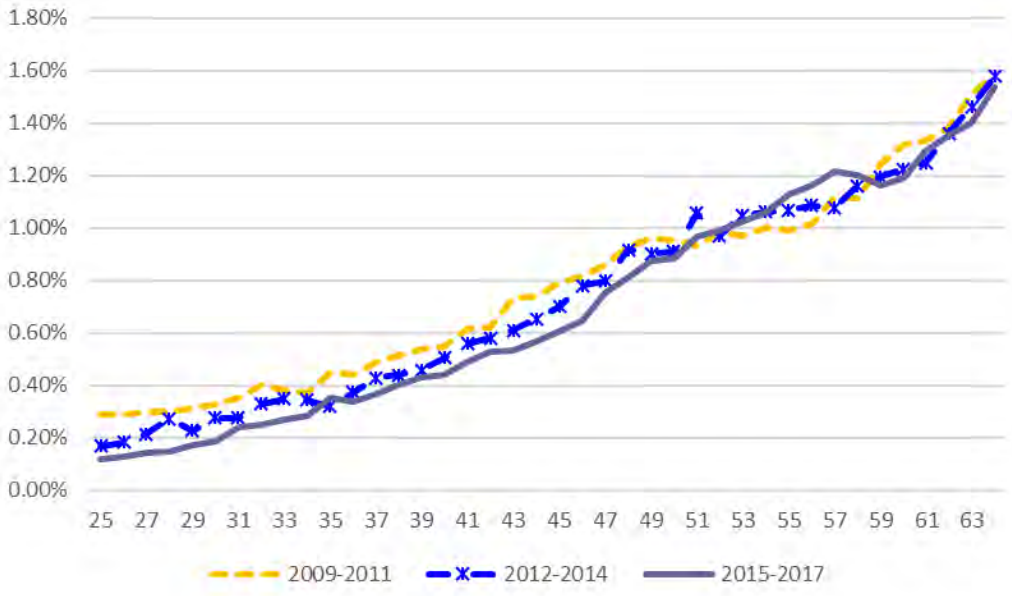
Appendix B. Mortality Trend of Three Groups of NPI Participants

Figure B-1
MORTALITY RATES OF PARTICIPANTS STAYING IN NORTHERN TAIWAN (2009-2017)



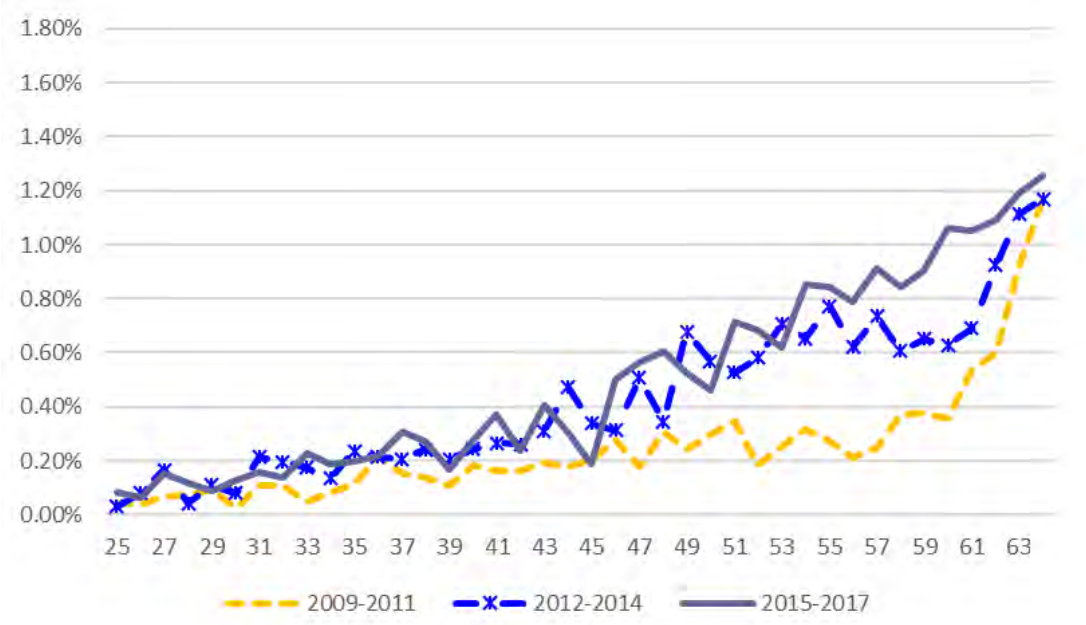
Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Figure B-2
MORTALITY RATES OF PARTICIPANTS STAYING IN NON-NORTHERN TAIWAN (2009-2017)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

Figure B-3
MORTALITY RATES OF MIGRATION PARTICIPANTS (2009-2017)



Source: Compiled based on NPI data, collected by Bureau of Labor Insurance (BLI).

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