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Do domestic immigrants live longer? An approach for estimating the life expectancy of small populations

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Abstract

Ageing is a major demographic issue for the world of the 21st century and is caused by substantial declines in fertility and mortality rates. Without international migration, most developed countries would not be able to balance the resulting losses of population and work force. The proportion of elderly (aged 65 and over) in Taiwan reached the threshold of 7%, indicating an ageing society, in 1993, and has been increasing dramatically since then. The county-level populations in Taiwan are also ageing rapidly, but the local changes vary widely because domestic migration rates of each county are different. Urbanization is becoming more obvious, with people tending to move to large cities and counties with better social welfare programs. As a result, domestic migration plays an important role in population ageing at the county level, and the people in counties with larger numbers of domestic immigrants are expected to have a longer life expectancy. However, the life expectancies of people in these counties do not bear out this trend. In the present study, based on domestic migration records from the Department of the Interior of Taiwan, we applied graduation methods and small-area estimation skills to construct county-level life tables, and evaluate whether domestic immigrants have lower mortality rates than those who do not migrate. We found that the domestic immigrants of Kinmen County have significantly lower mortality rates, but those of Hsinchu County do not.

Keywords: *Domestic migration, small area estimation; life expectancy; smoothing methods; population ageing.*

Introduction

Taiwan reached the threshold of becoming an ageing society where the proportion of the elderly reaches at least 7% in 1993, and since then ageing of the population has accelerated. For example, the proportion of Taiwan's elderly age 65 and over was about 12% in 2014, and is expected to reach 20% in 2025 (National Development Council, 2014). The most important factors causing this rapid ageing of the population are decreasing fertility rates and prolonged life expectancy. For example, the total fertility rate (TFR) of Taiwan reached six in the 1960's, and has been jumping around 1.2 for the past 7 years (2011–2017) (Department of the Interior of Taiwan, retrieval date 2018/11/28). Likewise, the life expectancies of men and women in Taiwan increased from lower than 60 in the early 1960's to approximately 77 and 83, respectively, today. Because Taiwan does not have a large amount of international migration, the population tends to age faster than in other developed countries.

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We can also observe the influence of the TFR and life expectancy on the population growth rate. The growth rate of Taiwan's population peaked in the 1980's and has since slowed. This trend matches the pattern of the TFR, in particular, where the TFR dropped below the replacement level in 1983. However, the speed of population ageing varies widely for different counties in Taiwan, a trend that is mainly caused by internal migration. Figure 1 shows the population growth rates of Taiwan's counties with emphasis on Kinmen and Hsinchu counties and that of Taiwan as a whole. Although the populations of most counties and overall growth rates are decreasing, the growth rate of Kinmen County is increasing, and that of Hsinchu County has remained constant.

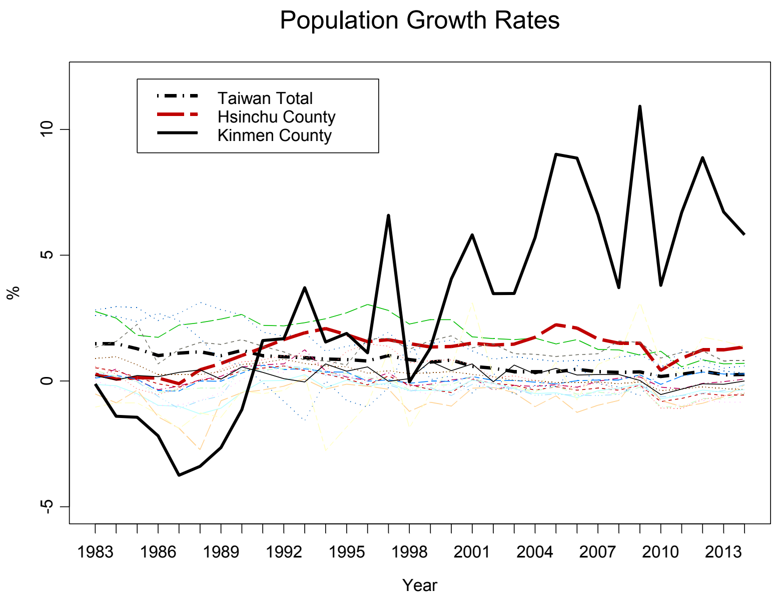

Figure 1. Population Growth Rates of Kinmen County, Hsinchu County, and Taiwan (1983–2014)

The present study used Kinmen County to demonstrate the effect of domestic migration on population size and structure. Kinmen County was once a restricted area where people were not allowed to move freely, resulting in practically no domestic migration before 1990. Migration had been restricted because Kinmen County was a war zone in the 1950's and 1960's during the war between the Taiwanese government and mainland China. The government revoked the restriction of county-to-county migration in the 1990's, and increased rates of domestic migration have occurred in the past 20 years (Figure 2). When further comparing the immigrating and emigrating populations since 1999, it can be seen that the net migration population in Kinmen County was about 66,325 people. Examining the age distribution (Figure 3) of immigrating and emigrating populations, Figure 2 shows that the net migration population mostly included people of working age. Since part of Kinmen County is less than one mile from the mainland, many people move there in order to engage in business with China. This is one of the reasons why there are more immigrants than emigrants to this county.

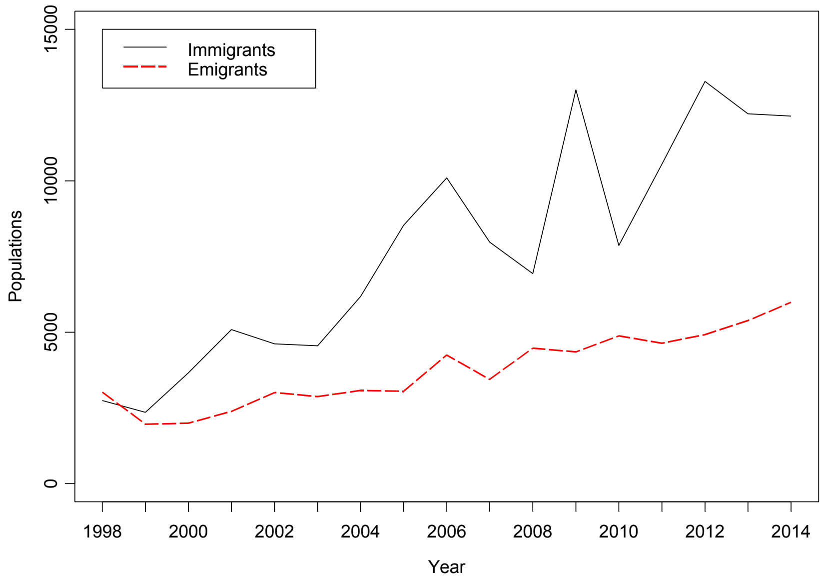

Figure 2. Annual Immigration and Emigration Rates for Kinmen County (1998–2014)

The effect of population inflow can be seen from the change in population structure. Figure 4 shows the population structure of Taiwan as a whole and Kinmen County separately, with respect to age groups of 0–14, 15–64, and 65 and over. Kinmen County once had a larger proportion of elderly people, but that percentage seems to have levelled off since 2003. However, the proportion of elderly people in Taiwan surpassed that of Kinmen County in 2012, and continued to grow. In addition, the proportion of people in Kinmen County actively participating in the work force (ages 15–64) has had a greater rate of increase, and the proportion of the younger generation (ages 0–14) decreased much faster than in Taiwan as a whole. These numbers indicate that there must be immigrants coming to Kinmen County in the age group 15–64.

In addition to the population structure, official statistics show that people in Kinmen County have the greatest longevity of all areas of Taiwan, even longer than that of those in Taipei City, the capital. This is against our belief that people in Taipei live longer since Taipei has the best resources in Taiwan. Kinmen County is an island at least 100 miles from Taiwan and does not have many resources, including medical resources and job opportunities. Table 1 lists the crude mortality rates of Taipei City, Kinmen County, and Hsinchu County. The crude mortality rates were lowest before 2009, and remained lower than the average in Taiwan. Kinmen County had the lowest crude mortality rates in 2009 and 2014, but the highest in 1994 and 1999. In contrast, the crude mortality rates of Hsinchu County, another county with a high number of domestic immigrants, did not show a similar pattern. We are interested in knowing why these two counties show such a difference in mortality rates, and in exploring whether the domestic immigrants live longer than permanent residents.

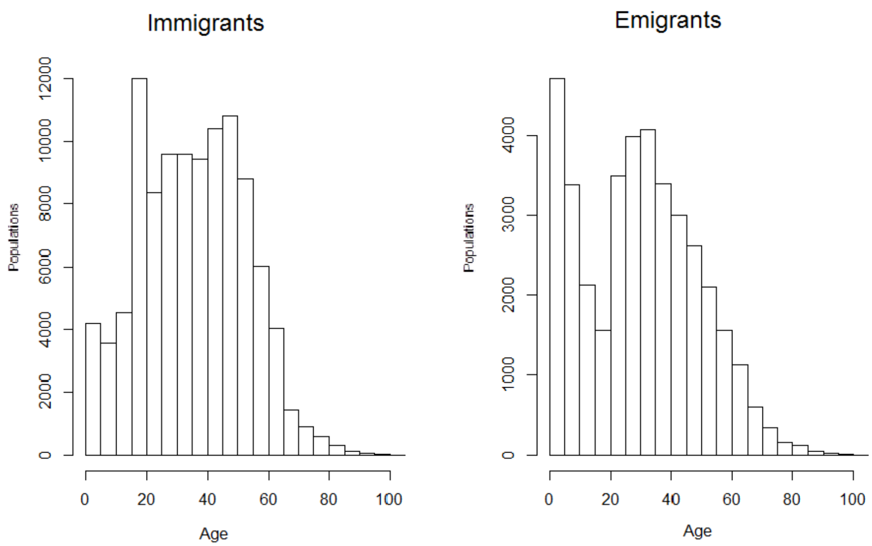

Figure 3. Age Distributions of Immigrants and Emigrants Populations in Kinmen County (1998–2014)

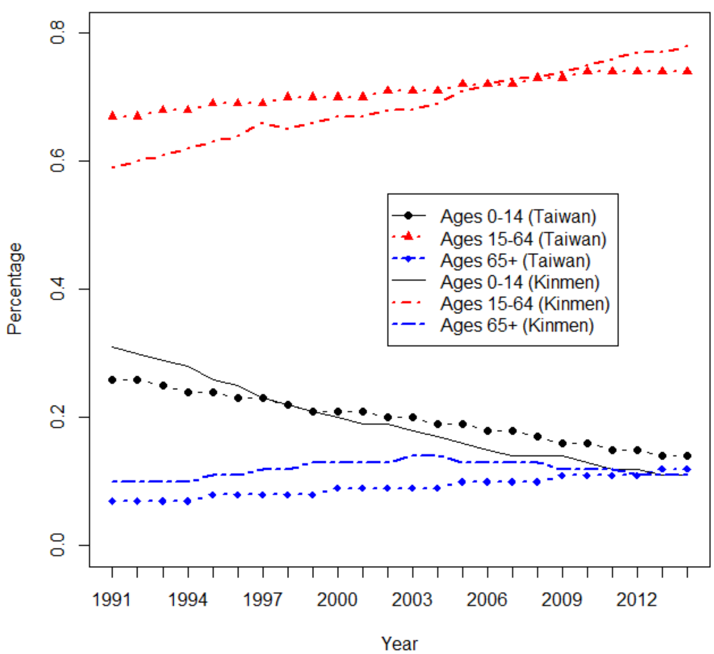

Figure 4. Population Structures of Taiwan and of Kinmen County (1998–2014): ages 0–14, 15–64, and 65+.

Table 1. Crude Mortality Rates of Taiwan, Taipei City, Kinmen County, and Hsinchu County Unit: ‰

	1994	1999	2004	2009	2014
Taiwan	5.38	5.73	5.94	6.21	6.97
Taipei City	4.25	4.81	5.30	5.85	6.30
Kinmen County	7.74	7.21	5.82	4.94	5.03
Hsinchu County	5.92	6.27	6.31	6.24	6.59

Review and Methodology

Most literature related to the study of population migration has focused on transnational migration. These studies explore differences with respect to life expectancy/health between immigrants and local people as well as discuss the factors that stimulate the motivation to migration. Migrant populations often have lower mortality rates. Singh and Miller (2004) compared the relationship between life expectancy and related diseases among local people and immigrants. Kibele et al. (2008) showed the migrant mortality in Europe is lower than those of host populations. Ng (2011) found a healthy immigrant effect, with lower overall rates among immigrants at Statistics Canada. Wallace and Kulu (2014) showed that most international migrants have lower mortality rates than natives in England and Wales. The migrant mortality rates can also vary for different races. Ott et al. (2009) pointed out that the arrival in Israel of migrants from the former Soviet Union was expected to cause a significant rise in Israel's mortality rates. Norredam et al. (2012) found that the immigrants generally had lower mortality rates than those of the refugees. Garcia et al. (2017) showed that the U.S. Mexican American population enjoys longer life expectancies relative to other racial/ethnic groups.

The Hispanic paradox is used most often to explain why the mortality rates of international migration are lower. Palloni and Arias (2004) found that a mortality advantage exists for Hispanics among foreign-born Mexicans and foreign-born Hispanics, especially for older people, and this advantage could be attributed to return migration, or the "salmon-bias" effect. Return migration will result in artificially lower mortality rates for the Hispanic population in Mexico. Markides and Eschbach (2005) showed the majority of the evidence continues to support a mortality advantage among Mexican Americans and especially for older men, which may provide partial and indirect support for a selective return migration or "salmon bias" effect (Bostean, 2013; Thomson et al., 2013; Andersson and Drefahl, 2015). Franzini et al. (2001) commented on possible problems in data related to vital statistics and proposed the hypothesis that the paradox may result from either a healthy immigrant effect or a salmon bias. In contrast, McKay et al. (2003) summarized 362 papers regarding the study of health related factors for immigrants and suggested a deeper investigation of the effects of disability on Latino mortality should be conducted. For example, Hayward et al. (2014) found low mortality rates among Hispanics are not matched by low disability rates while Goldman (2016) suggested that the Latino mortality advantage may soon disappear because obesity and diabetes among Latinos continue to increase.

Domestic migration also receives a considerable amount of attention from scholars and, similar to the studies of international migration, often the study goal is to explore the influence and driving forces of migration. Social welfare needs, medical demands, employment, and marriage have been proposed as driving forces. For example, Meyer (1998) pointed out that the social welfare benefits often induced migration. McKinnish (2005) found that social welfare benefits do affect migration decisions and Barrett and McCarthy (2008) showed that immigrants are often relatively heavy uses of welfare in most cases. The present study should only focus on past work that is related to life expectancy, because many related studies had been published. Johnson and Taylor (2012) studied elderly American Caucasians who made long-distance internal migrations and found that these migrants had reduced longevity because of their need of elder-care. Kibele and Janssen (2013) used Dutch census data related to senior citizens aged 80 and above, and found a regional mortality profile can be distorted by the health demands of elderly migrants. They pointed out that variations in regional mortality provide an important public health indicator and can be used for population forecasting and policy planning. Giulietti and Wahba (2013) suggested that immigration policies directly influenced the characteristics of immigrants. Preston and Elo (2014) confirmed that effective municipal policies and programs reflect the life expectancy of New Yorkers when compared with life expectancy in the United States as a whole. Black et al. (2015) showed that the great migration—defined as the massive migration of African Americans out of the rural South to largely urban locations in the North, Midwest, and West—increased mortality of African Americans born in the early twentieth century in the American South.

Other factors, such as natural traits (Gavrilov and Gavrilova, 2013), gender (Morokvašić, 2014; Yucesahin and Yazgan, 2017; Chort et al., 2017), temperature, and island effects have also been proposed as driving forces. Poulain et al. (2004) concluded that characteristics of the environment, genetic factors, or both could exert a favorable effect on men more strongly than on women. This was based on the observation on high prevalence of male centenarians in the "Blue Zone," Ogliastra in Sardinia, Okinawa in Japan, the Nicoya peninsula in Costa Rica, and the island of Ikaria in Greece. Willcox et al. (2008) supported the conclusion that the high prevalence of centenarians in Okinawa is valid and suggested its genetic and environmental correlates will require further study. Poulain (2011) called for a more in-depth validation of longevity in Okinawa. Poulain et al. (2013) observed that the "Blue Zone" population is geographically and/or historically isolated and it shares a common lifestyle, environment, and exceptional longevity.

The crude mortality rates for Taiwan in Table 1 appear to contradict the results from past studies. However, a crude mortality rate is sensitive to population structure, in that a higher proportion of the elderly in a population usually creates a higher crude mortality rate. We shall use the standard mortality ratio (SMR) to double check these results in Table 2. The SMR is defined as:

$$\text{SMR} = \frac{\sum_x d_x}{\sum_x n_x \cdot u_x} \qquad (1)$$

where d_x is the observed numbers of deaths for age x, n_x is the population of a small area at the age of x, and u_x is the mortality rate of the standard population at age x.

The SMR is calculated using a consistent age structure, i.e. free of the influence of population structure, and it often serves as a mortality index. Usually, the smaller the SMR, the larger the life expectancy. We reproduced the results of Table 1, but used the formula used to calculate SMR in Table 2. The population of Taiwan is employed here as a standard population. Judging from the SMR, Kinmen County still has had relatively small mortality rates in recent years, but it did not have the largest rates in the 1990's, unlike the results shown in Table 1. Nevertheless, similar to Table 1, the SMRs of Hsinchu County are almost identical to those of Taiwan as a whole. While these results are the same as those of Table 1, Kinmen and Hsinchu demonstrate different mortality behaviour. In the next section, we introduce methods of constructing life tables to further explore the issue of whether domestic immigrants live longer than permanent residents.

Table 2. Standardized Mortality Rates of Taiwan as a Whole, Taipei City, and Kinmen and Hsinchu Counties for 1994, 1999, 2004, 2009, and 2014

Unit: ‰

	1994	1999	2004	2009	2014
Taiwan	5.323	5.679	5.903	4.667	4.436
Taipei City	3.888	4.278	4.370	3.473	3.325
Kinmen County	4.837	4.990	4.014	3.378	3.169
Hsinchu County	5.479	5.859	5.956	4.686	4.516

The mortality rates are the most natural measure used for comparing life expectancy, but only if their estimates are reliable. Kinmen County supports a population of around 100,000, which means the male and female populations are around 50,000 each. The estimates of age-specific mortality rates usually fluctuate widely at this population size, so that graduation methods would be required to stabilize the estimates. In the present study, two types of graduation methods were considered: The Whittaker and Partial SMR (PSMR) methods. The Whittaker method (London, 1985) is used to minimize the following objective function, i.e., weighted sum of fit function F and smoothness function S:

$$M = F + \mathrm{hS} = \sum_{x=1}^{n} w_x (v_x - u_x)^2 + h \sum_{x=1}^{\text{n-z}} (\Delta^z v_x)^2 \quad (2)$$

where u_x and u_v are observed and graduated mortality rates for age x, respectively; w_x is the weight for age x; n is population size; and h and z are the parameters to be determined. In this study, we let h be the average population size of a single age and $z = 3$ as suggested in previous studies.

The PSMR (Lee, 2003) provided another way to deal with estimating mortality rates of small populations that involved adding information from other (large) populations to correct any possible bias. The revised mortality rate of a small population is a weighted geometric average of observed mortality rates and the SMR of a small population, treating the large population as the standard population, using Eq. (3):

$$v_x = u_x \times \exp\left(\frac{d_x \times \hat{h}^2 \times \log(d_x/e_x) + (1 - d_x/\sum d_x) \times \log(\mathrm{SMR})}{d_x \times \hat{h}^2 + (1 - d_x/\sum d_x)}\right). \quad (3)$$

A larger population with a mortality profile similar to the small population is preferred for use as the standard population when calculating Eq. (1) SMR. In Eq. (3), u_x is the mortality rate for age x in a large area, while d_x and e_x are the observed and expected numbers of deaths for age x, respectively, and $\hat{h}^2$ is the estimated value of the heterogeneity parameter h^2 in Eq. (4):

$$\hat{h}^2 = \max\left(\frac{\sum\left((d_x - e_x \times \mathrm{SMR})^2 - \sum d_x\right)}{\mathrm{SMR}^2 \times \sum e_x^2}\ ,\ 0\right) \quad (4)$$

The larger the $\hat{h}^2$, the larger the heterogeneity between the small and large regions mortality rates. The smaller the number of deaths, the higher the ratio of the smoothed value that refers to mortality rates from the large population, that is, $\mathrm{SMR} \times u_x$.

Evaluation of Graduation Methods

County-level population sizes are often small, and their observed age-specific mortality rates fluctuate significantly for consecutive ages. This is why graduation methods need to be applied to smooth the mortality rates when constructing life tables. However, the graduation methods cannot function well when the population size is too small. In our experience, when the population size is 200,000 or less, graduation methods (or mortality models) alone are usually not good enough (Wang et al., 2018). We need extra information from other populations (namely, reference populations) or an increase in the size of the small population. In the present study, we propose an approach that combines these two ideas at once, to reduce the fluctuations of mortality rates.

The proposed method is a modification of those in Wang et al. (2018), based on two graduation methods, the Whittaker and PSMR methods. First, we treated the sum of the historical data from a small population as the reference population, and then applied graduation methods with the information from the reference population to stabilize the mortality rates of the small population. We first needed to use computer simulation to evaluate whether the size of the reference population makes any difference. The results can be used to determine how many years of data from the small population are needed to form the reference population.

Suppose the mortality rates follow the Lee–Carter model (Lee and Carter, 1992), which means that the logarithm of age-specific mortality rates satisfies Eq. (5):

$$\ln(m_{x,t}) = \beta_x^{(1)} + \beta_x^{(2)}\kappa_t^{(2)} + \varepsilon_{x,t}. \qquad (5)$$

with two constraints, $\sum_x \beta_x^{(2)} = 1$ and $\sum_t \kappa_t^{(2)} = 0$, while $m_{x,t}$ is the central mortality rate of age *x* at year *t*, $\beta_x^{(1)}$ is average mortality rate of people age *x*, $\beta_x^{(2)}$ is the change rate of age *x*, $\kappa_t^{(2)}$ is the mortality intensity in year *t*, and $\varepsilon_{x,t}$ is the error term. Also, we used the population structure of Taiwan males from 1995–2014 and assumed the reference and small populations have the same age structure in Taiwan.

We use the mortality data for 1995–2004 to estimate the parameters of the Lee-Carter model, $\beta_x^{(1)}$, $\beta_x^{(2)}$, and $\kappa_t^{(2)}$, and to simulate the number of deaths, given the population structure of Taiwan and the age-specific mortality rates from the Lee-Carter model. Different sizes of small populations were considered, ranging from 10,000, 20,000,□ to one million, and the sizes of the reference population were 2 million, 5 million, and infinity (i.e., the mortality rates satisfied Eq. (5) without errors). The mortality rates of the small population were graduated using the Whittaker and PSMR methods, but those of the reference population were not graduated. Also, instead of graduating the mortality rates, we first computed the ratio of mortality rates from the small population to those of the reference population. Then, we applied the graduation methods to the mortality ratios; the graduated mortality rates were the products of the graduated ratios and the mortality rates from the reference population.

The simulation was repeated 1,000 times and the errors were computed according to the Mean Absolute Percentage Error (MAPE), or

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\frac{|\hat{y}_i - y_i|}{y_i} \times 100\%, \qquad (6)$$

where y_i represents the true mortality rate and $\hat{y}_i$ is the graduated mortality rate. According to Lewis (1982), a prediction with MAPE less than 10% is treated as highly accurate, and a MAPE greater than 50% is considered inaccurate. The average MAPEs of 20 years and 1,000 simulation runs are given in Table 3. Apparently, the graduation methods can reduce the errors, and the reduction rate decreases as the size of the small population increases. The errors without graduation were smaller than 10% when the population size was over 500,000, suggesting that graduation might not be necessary in this case.

As expected, smaller errors were found with the larger reference population, but few differences were observed between the small and reference populations. It seems that 2 million is sufficient for the reference population. As long as the reference and small populations have identical mortality rates and the size of the reference population is two million or more, the proposed graduation methods can effectively improve the estimates of mortality rates for the small population. In addition, the PSMR generally has smaller errors, similar to the results in Wang et al. (2012, 2018). However, in practice, it is difficult to find (and confirm) that the reference populations have mortality rates identical to the small population. This is why we treated the sum of historical data from the small population as the reference population. We also used computer simulation to evaluate the proposed approach. Again, the mortality rates were assumed to follow the Lee-Carter model and we used the Taiwan population structure of 1995–2014. The reference population represents the sum of data from 20 years, or the size of the reference population is about 20 times the size of the small population.

Table 3. Average Errors of Various Sizes of the Reference Population

MAPE: %

		10,000	20,000	50,000	100,000	200,000	500,000	1 mill.
Raw		64.48	47.62	30.33	21.08	15.06	9.45	6.71
Whittaker Ratio	Inf.	17.37	16.16	13.32	10.78	8.53	5.74	4.20
	5 mill.	18.15	16.46	13.48	11.05	8.76	6.31	4.74
	2 mill.	18.71	17.12	14.09	11.61	9.27	6.77	5.45
Partial SMR	Inf.	10.76	7.81	4.91	3.44	2.45	1.57	1.12
	5 mill.	11.91	8.54	5.93	4.87	4.02	3.45	3.16
	2 mill.	12.50	9.54	7.18	6.11	5.45	4.87	4.60

Note: SMR, standard mortality rate

The average errors from 1,000 simulation runs are given in Table 4. Because the small and reference populations do not have identical mortality rates, the results are somewhat different from those in Table 3. The PSMR had the fewest errors when the size of the small population was 200,000 or less, even smaller than those of the Lee-Carter model. This is an interesting result. The Lee-Carter model is an accurate model, but it seems that the estimation method (via singular value decomposition) was influenced by the small population size. Choosing appropriate graduation methods can provide more accurate mortality estimates, possibly better than those of the parametric models. However, the Whittaker method is not a good choice, and it has larger errors than those without graduation (or raw data).

Since the PSMR has better performance, we will only consider this method for the rest of this study. We shall use two examples to demonstrate the effects of applying PSMR to real data. First, we show the mortality rates of Kinmen County in 2014, before and after graduation (Figure 5). Obviously, the shape of age-specific mortality curves looks similar for those before and after graduation. Because no deaths were observed for quite a few age groups, their raw mortality rates are 0 (or NA in logarithm). It appears that the PSMR reduces the fluctuations of age-specific mortality rates.

Table 4. Estimated Errors of Different Graduation Methods

MAPE: %

	10,000	20,000	50,000	100,000	200,000	500,000	1 mill.
Raw	68.23	50.59	32.90	22.88	16.28	10.27	7.26
Whittaker	51.54	38.20	27.62	22.68	19.82	17.70	16.88
Lee-Carter	33.57	23.67	15.53	10.97	8.66	6.05	4.05
PSMR	14.31	11.75	9.68	8.70	8.09	7.50	7.03

Note: PSMR, partial standard mortality ratio

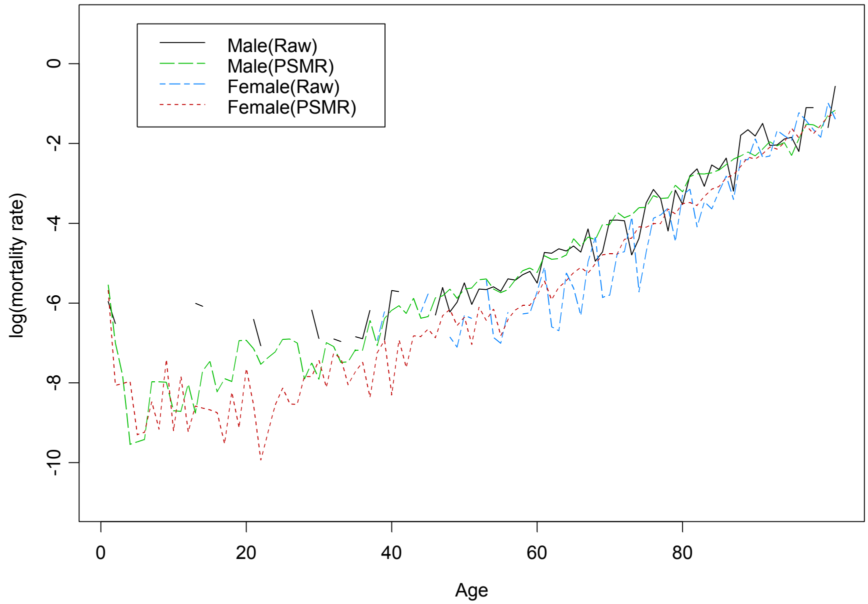

Figure 5. Raw and Graduated (SMR) Mortality Rates of Kinmen County (2014)

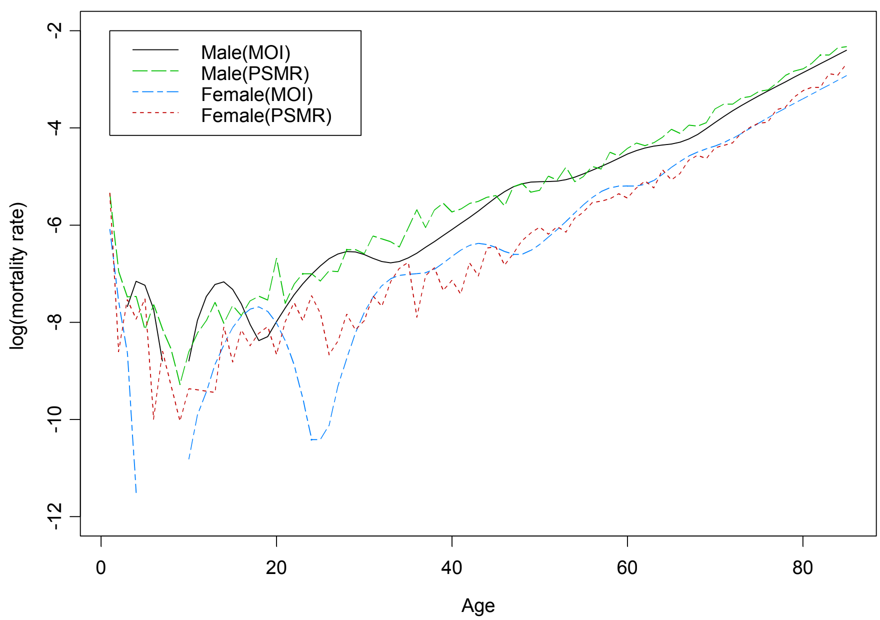

Figure 6. Varies Graduated Mortality Rates of Penghu County (2014)

Note: MOI indicates the mortality rates from Ministry of the Interior and PSMR are those from Partial Standard Mortality Ratio

We also applied the PSMR approach to another county in Taiwan, Penghu County. Penghu is an island county with a small population. Penghu County was chosen to demonstrate the effectiveness of the proposed approach in the case of a population size around 100,000, which is about the size of that in Kinmen County. The PSMR can reduce the fluctuations of age-specific mortality rates, even when no deaths are observed for certain age groups in Penghu County. Of course, the PSMR can be applied to other counties and is not restricted to small islands or populations with certain demographic characteristics. However, unlike Kinmen County, Penghu County has official life tables that are released every year from the Ministry of the Interior (MOI). Thus, we can compare the mortality rates of Penghu County via PSMR to those from the official life tables. Figure 6 shows the logarithms of mortality rates for both genders. Similar to Figure 5, several age groups had no observed deaths, and thus some of the official mortality rates are 0 while the mortality curve shows many fluctuations. The mortality curve of PSMR is smoother, although the mortality rates of some ages can show more graduation.

Empirical Analysis

We used the official population records to explore whether the domestic immigrants have lower mortality rates. Taiwan has been using a population registration system since it was occupied by Japan in the early 20th century. People in Taiwan are required to report changes in records for certain personal events, such as marriages, divorces, or relocations (change of address). A penalty is imposed for any delay in reporting or failure to report such events. The data quality of Taiwan's population registration system is generally good and reliable, because individuals' legal rights are based on these records.

Two counties of interest, Kinmen and Hsinchu, have more immigrants than emigrants. However, the age structure of domestic migrants is not the same in these two counties, as can be seen by comparing the age structures of people residing to Kinmen and Hsinchu counties in different years. However, similar to the previous section, the small population size of Kinmen County makes data analysis difficult. Therefore, to simplify data analysis, we first separated the residents in Kinmen and Hsinchu counties into two groups: people residing there more than or less than 10 years. If differences exist between these two groups, we can further refine the grouping.

Table 5 shows the percentages of population and deaths for those residing more than 10 years in Kinmen and Hsinchu counties between 2012 and 2014. On average, those residing in Kinmen more than 10 years' account for about 43% of the population, but almost 70% of all deaths. Similarly, about 74% of the population are those residing in Hsinchu more than 10 years, and they account for almost 90% of all deaths. It seems that the long-time residents have higher mortality rates or perhaps new immigrants have lower mortality rates.

Table 5. Percentages of Populations and Deaths for Those Residing more than 10 Years in Kinmen and Hsinchu Counties

		2012		2013		2014	
		Male	Female	Male	Female	Male	Female
Population	Kinmen	44.43%	43.99%	43.55%	42.47%	43.61%	42.27%
	Hsinchu	70.58%	67.64%	70.77%	68.07%	71.07%	68.36%
Deaths	Kinmen	75.00%	82.40%	71.70%	71.90%	76.10%	78.80%
	Hsinchu	90.90%	89.90%	90.30%	90.10%	89.70%	92.40%

Note that the proportion of the population in age group 15–64 in Kinmen County has increased, while the proportions of age groups 0–14 and 65+ decreased (Figure 3). This indicates that a large percentage of immigrants were in the age group 15–64. Thus, similar to the problem in judging the crude mortality rates in Table 1, we cannot decide whether the immigrants have lower mortality rates based on the proportions of population and deaths alone.

Figure 7 shows the age-specific mortality rates of people residing in Kinmen (2012–2014) for more than or less than 10 years. Three years of data were considered to increase the population size and reduce the fluctuations in mortality rates; this is exactly what we used in constructing the complete life tables in Taiwan (MOI). In general, people residing in Kinmen less than 10 years have lower mortality rates than long-term resident, and this is more obvious for males. For females, the people residing in Kinmen less than 10 years have lower mortality rates for those aged 50 and over.

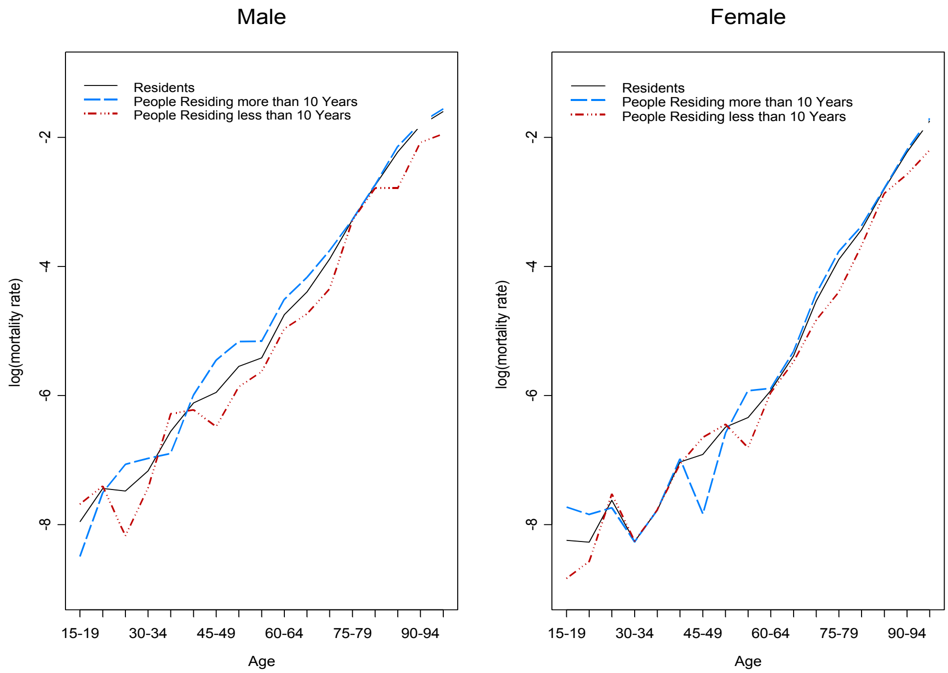

Figure 7. Raw Mortality Rates in Kinmen County (2012–2014): Immigrants vs. Long-term Residents

We expect that the life expectancy of people residing in Kinmen less than 10 years to be longer than for those residing more than 10 years, and that the difference should be larger for males. In addition, we tried to refine the grouping into those residing in Kinmen 0–4, 5–9, and more than 10 years. The results are similar and indicate that newer immigrants have lower mortality rates. However, because of the limitation caused by population size, we only show the results of two groups: those residing in Kinmen less than or more than 10 years.

The case of Hsinchu County is different. Those residing in Hsinchu less than 10 years still have lower mortality rates for the younger age groups, but have about the same mortality rates for those aged 50 and over. Because the differences are minor and affects those of younger ages, we believe the new immigrants might have longer lives (Figure 8).

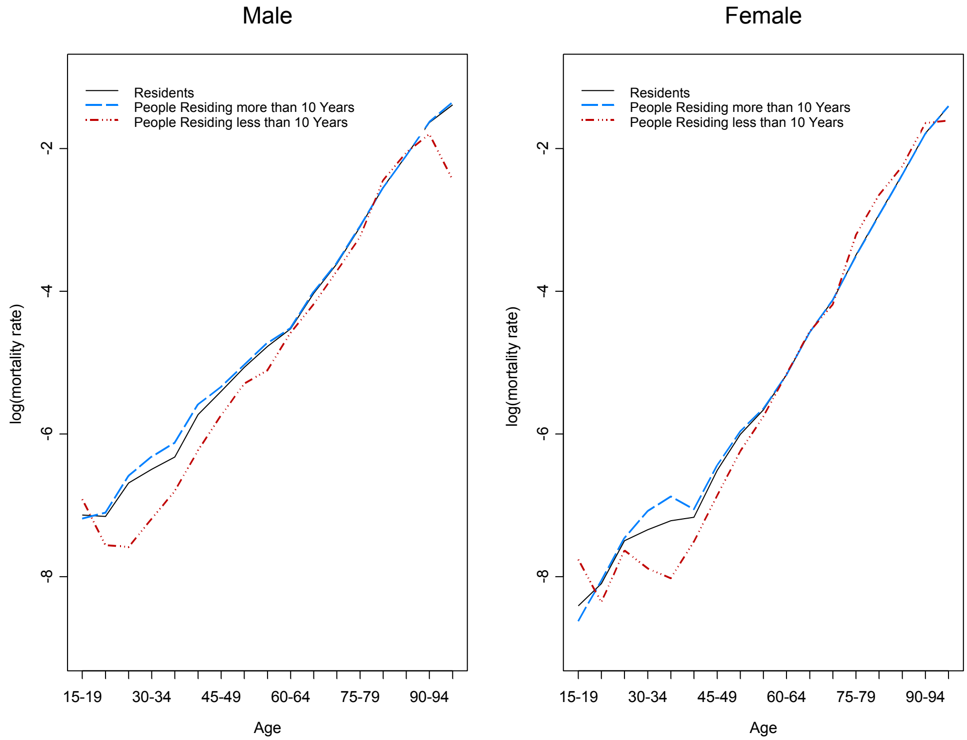

Figure 8. Graduated Mortality Rates in Hsinchu County (2012–2014): Immigrants vs. Longterm Residents

Similar to the data presented in Table 2, Kinmen County has had smaller SMRs in recent years with people expected to have longer life expectancies than those in Taipei City. However, we found that new immigrants have lower mortality rates in Kinmen County. If we only count the residents residing in Kinmen for more than the last 10 years, their life expectancy would be closer to that of residents in Taipei. To double check, Table 6 lists the SMRs of different groups of residents in Taipei city as well as in Kinmen and Hsinchu counties. Kinmen males had the greatest differences of SMRs, matching the results in Figure 7. If we consider only those residing in Kinmen more than 10 years, the life expectancy of Kinmen males would be about the same as that of Taipei males.

However, the effects of new immigrants were not very obvious for Kinmen females. We would expect the life expectancy of Kinmen females to be longer than females of Taipei, no matter whether we reviewed data for all Kinmen residents or for those residing there more than 10 years. As for Hsinchu County, because the immigrants do not have significantly lower mortality rates than long-term residents, the SMR and life expectancy did not have obvious changes.

We can also use the proposed graduation method, the PSMR, to demonstrate the effects of new immigrants on the mortality rates in Kinmen County. The reference population is the sum of mortality data in Kinmen County. Figure 9 shows the graduated mortality rates for those residing in Kinmen less and more than 10 years, as well as for all residents in Kinmen. The mortality curves are fairly smooth for populations having at most 40,000 inhabitants. After graduation, the advantage of low mortality rates for new immigrants is more noticeable, and the mortality curve of all residents fell between those of people living here for less or more than 10 years.

Table 6. Standard Mortality Ratio for Males and Female Residents of Taipei City, Kinmen and Hsinchu Counties (2012–2014) Including Resident of Kinmen County Who Have Resided Here More Than Ten Years

	Male			Female		
	2012	2013	2014	2012	2013	2014
Taipei City	0.78	0.77	0.76	0.81	0.79	0.77
Kinmen County	0.78	0.71	0.71	0.58	0.60	0.70
Kinmen County (10+ Year Residents)	0.90	0.79	0.83	0.65	0.58	0.78
Hsinchu County	0.96	1.01	0.98	1.00	1.02	0.97
Hsinchu County (10+Years Residents)	1.00	1.03	1.01	1.01	1.02	1.03

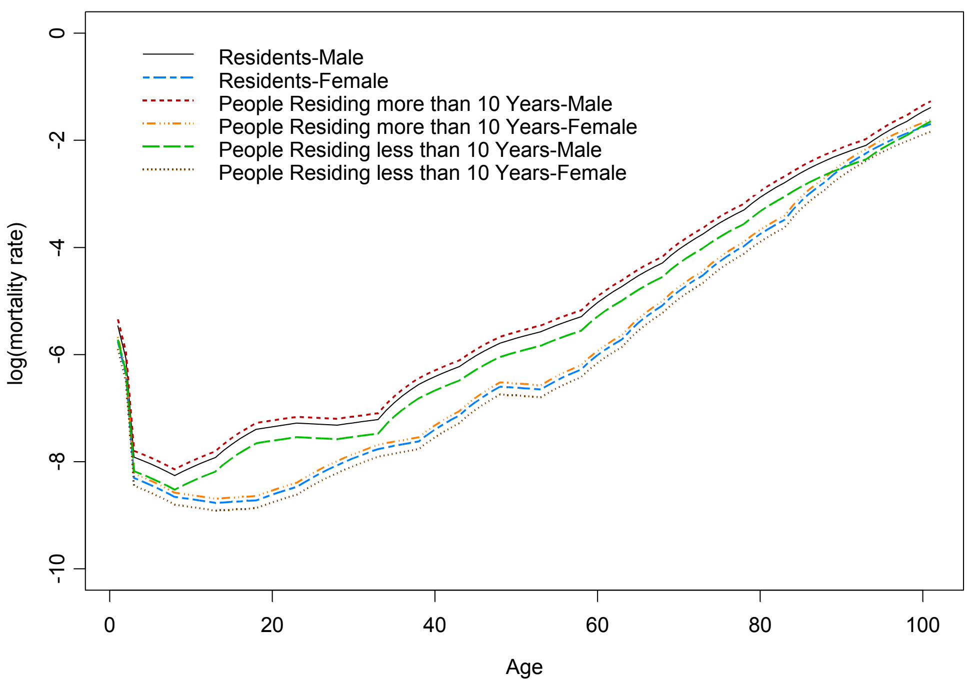

Figure 9. Graduated Mortality Rates in Kinmen County (2012–2014) for Males and Females, Including People Residing Here More or Less Than Ten Years.

Discussion

Although Taiwan is not a large country (covering less than 36,000 km^2), a substantial array of demographic differences exists within the local populations. For example, the population density at the county level varies significantly, ranging from about 60 to almost 10,000 persons per km^2; the largest difference in life expectancy at the county level is more than nine years (80.3 for Taipei males vs. 71.1 for Taitung males). These differences indicate inequity in resources, such as job opportunities and medical facilities, and thus create an incentive for domestic migration. Larger numbers of people tend to move to metropolitan areas, where the six most populous cities account for almost 70% of Taiwan's population, with only 30% of the remaining areas in the country.

Kinmen is a remote island and was once a war zone and restricted area. It was believed that life expectancy in Kinmen would be significantly lower than in Taiwan. However, this has changed; official statistics show that Kinmen has the longest life expectancy of anywhere in Taiwan, and it is even longer than in Taipei. Officials of the Taiwanese government have attempted to determine the causes of the rapidly increasing life expectancy in Kinmen County. One possibility is that many people immigrate to Kinmen County. Unlike the regular trend of domestic migration (from rural areas to the six most populous cities of Taiwan), more and more people have been moving to Kinmen for the last 20 years. The population of Kinmen has more than tripled, from 40,000 to more than 130,000.

In this study, we analyzed two counties with the largest proportions of domestic immigration and tried to clarify whether the immigrants have lower mortality rates. The results are interesting. The empirical studies of Taiwan migration data show diverse results and this suggests that the result of Kibele and Janssen (2013) cannot fully explain why the domestic migrant populations have lower mortality rates. Immigrants do have lower mortality rates in Kinmen County, but that is not the case in Hsinchu County.

It is believed that at least three factors are associated with the longer life of people in Kinmen County: The Household Registration System, welfare policies, and the Island Effect. These factors are not the same as those of international migration. First, as noted above Taiwan has had a household registration system since the early 20th century. A large difference may exist between the numbers of Taiwan's permanent (or residential) population and its officially registered population, especially for remote areas such as Kinmen County, which stands on an outlying island 200 miles west of Taiwan. In contrast, Hsinchu County lies close to Taiwan's capital, about one hour driving distance. In other words, people appear to "move" to Kinmen County solely to obtain a Kinmen registration record, but do not actually physically relocate. According to the 2010 population census in Taiwan, the actual number of permanent residents was only 63.1% of those registered as living in Kinmen County, while this number was 79.5% in Hsinchu County.

Second, the local government of Kinmen County has implemented welfare policies in recent years to attract domestic migrants, including the "Three-mini-links" for business people working between Kinmen and China. Although Taiwan and China have been in a formal state of hostility for over 60 years, it is possible to have direct trade between these two, and Kinmen County is one of the trade hubs. Many people between the ages 40 and 60 move to Kinmen in order to enjoy the privilege of conducting trade with mainland China. Kinmen County has excellent social welfare programs when compared with other counties in Taiwan. For example, the local government of the county gives monthly pensions to elderly residents, and students of Kinmen University receive a waiver of tuition if they choose to become county residents. As a result, the population of Kinmen almost tripled in 20 years from about 46,000 in 1994 to 127,000 in 2014. Nevertheless, the population in Hsinchu County increased from 401,000 to 538,000 during the same time period, a 40% increase; most of the immigrants were attracted by high-tech manufacturers, such as TSMC. It is likely that the increase of life expectancy in Kinmen was caused by a healthy immigrant effect, or a "salmon bias" (Giulietti and Wahba, 2013; Willcox et al., 2008; Poulain et al., 2004, 2013; McKinnish, 2005; Franzini et al., 2001).

Another factor is related to the Island Effect, or the survivor effect. The Island Effect is related to a discussion of the residents of Okinawa, who enjoy a longer life expectancy than those of Japan as a whole. Although individuals in Okinawa have lower income than people elsewhere in Japan, they enjoy a better quality of life; this is also true for residents of Kinmen County when compared with people in greater Taiwan. Kinmen was a war zone in the 1950's and 1960's; martial law remained in effect until 1992. People were not allowed to move in or out of Kinmen under martial law without the approval of government. Thus, few people immigrated and emigrated before 1992, compared with around 12,000 immigrants and 6,000 emigrants in 2014. People who survived during war usually have relatively low mortality rates such as Taiwan's veterans, survivors of civil war in China (1950–1979), still have a relatively long life expectancy (Chang et al., 2006). In fact, we believe that the residents of Kinmen who experienced the civil war also have better health as well as lower mortality rates than the people of Taiwan as a whole. We used the cancer incidence rates of these populations as an example. We calculated the 1993–2014 standardized incidence rate of cancer per 100,000 population for cities and counties in Taiwan, using the world population in 2000 as the standard population (Data source: Cancer Registry, Health Promotion Administration, Ministry of Health and Welfare, Taiwan). Table 7 shows that the Kinmen County had the smallest standardized incidence rate for cancer in all years.

Table 7. Standardized Incidence Rates of Cancer for Residents of Taiwan, Taipei, and Kinmen and Hsinchu counties, Per 100,000 Population for 1994, 1999, 2004, 2009, and 2014 (2000 World Population as the Standard Population for comparison)

		1994	1999	2004	2009	2014	1993–2014 (Average)
Taiwan	Male	203.50	284.00	316.95	346.08	345.62	295.79
	Female	164.22	221.15	235.26	261.19	274.41	226.77
Taipei City	Male	214.74	281.56	282.46	300.68	288.29	276.03
	Female	191.88	245.94	236.10	277.54	281.54	244.79
Kinmen County	Male	129.48	134.93	321.24	188.63	147.17	176.85
	Female	80.05	123.31	214.88	108.81	112.81	111.29
Hsinchu County	Male	163.91	205.48	258.57	269.48	289.78	229.02
	Female	158.59	178.61	214.60	234.23	239.12	197.65

Many things cause domestic migration, and not all immigrants would benefit from moving to a new place. It is still too early to arrive at a solid conclusion with the limited data available for the present study. Perhaps we can collect more data and separate the immigrants according to personal attributes such as age, income, and marital status. Combining that data with the information on origin and destination, we might produce a better picture of immigrant life expectancy.

As for technical developments in this study, we found that the graduation methods help to provide more stable estimates of mortality rates. If we can find good reference populations, the estimates can be more accurate than those obtained using parametric models. In addition, if the mortality rates are related to the time of migration, then we can propose an approach by modifying the estimation of select-and-ultimate table from commercial insurance data.

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References

Andersson G. and Drefahl S. (2015). "Long-distance migration and mortality in Sweden: testing the salmon bias and healthy migrant hypotheses". Research Reports in Demography, Stockholm University, http://www.suda.su.se/SRRD/SRRD_2015_6.pdf.

Barrett A. and McCarthy Y. (2008). "Immigrants and welfare programmes: exploring the interaction between immigrants characteristics, immigrant welfare dependence and welfare policy". Oxford Review of Economic Policy, 24(3): 542-59. https://doi.org/10.1093/oxrep/grn026

Black D.A., Sanders S.D., Taylor E.J., and Taylor L.J. (2015). "The impact of the great migration on mortality of African Americans: evidence from the deep south". American Economic Review, 105 (2): 477-503. https://doi.org/10.1257/aer.20120642

Bostean G. (2013). "Does selective migration explain the Hispanic paradox? A comparative analysis of Mexicans in the U.S. and Mexico". Journal of immigrant and minority health, 15(3): 624-35. https://doi.org/10.1007/s10903-012-9646-y

Chang H., Hu Y.W, Yue C.S., Wen Y.W., Yeh W.T., Hsu L.S., Tsai S.Y., and Pan W.H. (2006). "Effect of potassium-enriched salt on cardiovascular mortality of elderly men". American Journal of Clinical Nutrition, 83: 1289-1296. https://doi.org/10.1093/ajcn/83.6.1289

Chort I., De Vreyer P., and Zuber T. (2017). "Gendered internal migration patterns in Senegal". https://hal.archives-ouvertes.fr/hal-01497824/document.

Franzini L., Ribble, J.C., and Keddie, A.M. (2001). "Understanding the Hispanic paradox". Ethnicity and Disease, 11: 496-518.

Garcia M.A., Valderrama-Hinds L.M., Chiu, C.T., Mutambudzi M.S., Chen N.W., and Raji M. (2017). "Age of migration life expectancy with functional limitations and morbidity in Mexican Americans". Journal of the American Geriatrics Society, 65(7): 1591-1596. https://doi.org/10.1111/jgs.14875

Gavrilov L.A. and Gavrilova N.S. (2013). "Determinants of exceptional human longevity: new ideas and findings". Vienna Yearbook of Population Research, 11: 295-323. https://doi.org/10.1553/population yearbook2013s295

Giulietti C. and Wahba J. (2013). "Welfare migration". In: Constant AF, Zimmermann KF (eds.) International Handbook on the Economics of Migration, Edward Elgar Publishing, Cheltenham, UK, Northampton, US, 489-504. https://doi.org/10.4337/9781782546078.00036

Goldman N. (2016). "Will the Latino mortality advantage endure?". Research on Aging, 38(3): 263-282. doi:10.1177/0164027515620242.

Hayward M.D., Hummer R.A., and Chiu C.T., González-González C., Wong R. (2014). "Does the Hispanic paradox in U.S. adult mortality extend to disability?". Population Research and Policy Review, 33: 81-96. Doi:10.1007/s11113-013-9312-7.

Johnson J.E. and Taylor E.J. (2012). "Does moving kill? The effect of migration on older-age mortality". Retrieved from http://harris.uchicago.edu/sites/default/files/johnson_taylor_oct15.pdf .

Kibele E. and Janssen F. (2013). "Distortion of regional old-age mortality due to late-life migration in the Netherlands". Demographic Research, 29(5):105-132. https://doi.org/10.4054/DemRes.2013.29.5

Kibele E., Scholz R., and Shkolnikov V. (2008). "Low migrant mortality in Germany for men aged 65 and older: fact or artifact?". Eur J Epidemiol, 23: 389-393. https://doi.org/10.1007/s10654-008-9247-1

Lee R.D. and Carter L.R. (1992). "Modeling and forecasting US mortality". Journal of the American Statistical Association, 87(419): 659-671. https://doi.org/10.1080/01621459.1992.10475265

Lee W.J. (2003). "A partial SMR approach to smoothing age-specific rates". Annals of Epidemiology, 13(2): 89-99. https://doi.org/10.1016/S1047-2797(02)00266-1

Lewis E.B. (1982). "Control of body segment differentiation in Drosophila by the bithorax gene complex". In Embryonic Development, Part A: Genetics Aspects. Edited by M. M. Burger and R. Weber. Alan R. Liss, New York, 269-288. https://doi.org/10.1007/978-1-4419-8981-9_15

London R.L. (1985). Graduation: The Revision of Estimates. ACTEX Publication.

Markides K.S. and Eschbach K. (2005). "Aging, migration, and mortality: current status of research on the Hispanic paradox". The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences, 68-75. https://doi.org/10.1093/geronb/60.Special_Issue_2.S68

McKay L., Macintyre S., and Ellaway A. (2003) "Migration and health: A review of the international literature". MRC Social & Public Health Sciences Unit Occasional Paper. Retrieved from http://www.msoc-mrc.gla.ac.uk.

McKinnish T. (2005). "Importing the poor: welfare magnetism and cross-border welfare migration". Journal of Human Resources, 40(1): 57-76. https://doi.org/10.3368/jhr.XL.1.57

Meyer B.D. (1998). "Do the poor move to receive higher welfare benefits?". JCPR Working Papers 58, Northwestern University/University of Chicago Joint Center for Poverty Research.

Morokvašić M. (2014). "Gendering migration". Migracijske i Etničke Teme, 31 (3): 355-378. https://doi.org/10.11567/met.30.3.4

Ng E. (2011). "The healthy immigrant effect and mortality rates". Health Reports, 22: 25-29.

Norredam M., Olsbjerg M., Petersen J.H., Juel K., Krasnik A. (2012). "Inequalities in mortality among refugees and immigrants compared to native Danes - a historical prospective cohort study". BMC Public Health, 12(757): 1-9. https://doi.org/10.1186/1471-2458-12-757

Ott J.J., Paltiel A.M., Becher H., (2009). "Noncommunicable disease mortality and life expectancy in immigrants to Israel from the former Soviet Union: country of origin compared with host country". Bull. World Health Organ, 87: 20-29. https://doi.org/10.2471/BLT.07.045138

Palloni A. and Arias, E. (2004). "Paradox lost: explaining the Hispanic adult mortality advantage". Demography, 41: 385-415. https://doi.org/10.1353/dem.2004.0024

Poulain M. (2011). "Exceptional longevity in Okinawa: A plea for in-depth validation". Demographic Research 25 (7): 245−284. DOI:10.4054/DemRes.2011.25.7. https://doi.org/10.4054/DemRes.2011.25.7

Poulain M., Herm A., Pes G. (2013). "The Blue Zones: areas of exceptional longevity around the world". Vienna Yearbook of Population Research, 11: 87-108. https://doi.org/10.1553/population yearbook2013s87

Poulain M., Pes G., Grasland C., Carru C., Ferrucci L., Baggio G., Franceschi C., and Deiana L. (2004). "Identification of geographic area characterized by extreme longevity in the Sardinia island: the AKEA study". Experimental Gerontology, Elsevier, 39(9):1423-1429. https://doi.org/10.1016/j.exger. 2004.06.016

Preston S.H. and Elo I.T. (2014). "Anatomy of a municipal triumph: New York city's upsurge in life expectancy". Population and Development Review, 40(1):1-29. https://doi.org/10.1111/j.1728-4457.2014.00648.x

Singh G.K. and Miller B. A. (2004). "Health, life expectancy, and mortality patterns among immigrant populations in the United States". Canadian Journal of Public Health, 95(3), 114-21.

Thomson E.F., Nuru-Jeter A., Richardson D., Raza F., and Minkler M. (2013). "The Hispanic paradox and older adults' disabilities: is there a healthy migrant effect?". International Journal of Environmental Research and Public Health, 10(5): 1786-814. https://doi.org/10.3390/ijerph10051786

Wallace M., Kulu H. (2014). "Low immigrant mortality in England and Wales: a data artefact? ". Social Science & Medicine, 120:100-109. https://doi.org/10.1016/j.socscimed.2014.08.032

Wang H.C., Jin S., and Yue J.C. (2012). "A simulation study of small area mortality projection". Journal of Population Studies, 45: 77-110. (In Chinese).

Wang H.C., Yue C.J. and Chong C.T. (2018). "Mortality models and longevity risk for small populations". Insurance Mathematics and Economics, 78, 351-359. https://doi.org/10.1016/j.insmatheco.2017.09.020

Willcox D.C., Willcox B.J., He Q., Wang N., and Suzuki M. (2008). "They really are that old: a validation study of centenarian prevalence in Okinawa". Journal of Gerontology: Biological Sciences, 63A (4), 338-349. https://doi.org/10.1093/gerona/63.4.338

Yucesahin M.M. and Yazgan P. (2017). Revisiting Gender and Migration. Transnational Press London.