Authors: Jack C. Yue[1] and Hong-Chih Huang [2]

1. Professor, Department of Statistics, National Chengchi University, Taipei, Taiwan,

    R.O.C. 11605; csyue@nccu.edu.tw

2. Professor, Department of Risk Management and Insurance, National Chengchi

    University, Taipei, Taiwan, R.O.C. 11605; jerry2@nccu.edu.tw

Title of the paper: A Study of Incidence Experience for Taiwan Life Insurance

Running Title: Taiwan Life Insurance Incidence Experience

Number of Words: 4,985

Correspondence to:

Dr. Jack C. Yue

Department of Statistics

National Chengchi University, Taipei

Taiwan, ROC 11605

Tel: +886-2-2938-7695, Fax: +886-2-2939-8024

e-mail: csyue@nccu.edu.tw

ABSTRACT

Mortality improvement has become a major issue in ratemaking for insurance companies, and ratemaking is especially difficult in Taiwan. There are two reasons for this difficulty: population size and rapid improvement in mortality. Because the history of life insurance in Taiwan is relatively short, all life insurance products are typically offered based on the same experience life table, which is constructed based on the population purchasing all types of life insurance products in Taiwan. In this study, we used experience data from Taiwan life insurance companies to explore whether there are risk factors related to mortality rates. The experience data will also be used to evaluate whether the customers of life insurance companies possess mortality patterns similar to that of the overall population in Taiwan.

Keywords: Mortality Improvement, Experience Rate, Risk Factor, Life Table, Logistic Regression

1. INTRODUCTION

Mortality improvement has been a popular topic in the insurance business, and human life expectancy is likely to increase in the near future. The life expectancy of people in Taiwan has increased significantly since the end of World War II; the change became even more noticeable after the National Health Insurance (NHI) act was enforced in 1995. For example, the life expectancies of Taiwanese males and females were 72 and 78 years, respectively, in 1998, lower than the respective expectancies of 73 and 79 for U.S. men and women in 1998. According to the Ministry of the Interior of Taiwan, however, the life expectancies in Taiwan have now surpassed those in the U.S.[1]. The life expectancy trends shown in Figure 1 provide a better look at the rapid increase in life expectancy in Taiwan compared to the U.S.
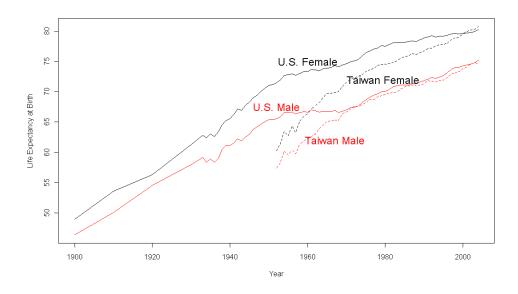

Figure 1. Life expectancies in Taiwan and the U.S.

Still, even though on average every person in Taiwan has owned at least two life insurance policies since 2008, approximately 1/3 of the population in Taiwan has

---

[1] http://www.moi.gov.tw/stat/

never purchased any life insurance products[2]. It is still unknown whether the population purchasing insurance products has a mortality profile similar to that of individuals who do not purchase these products. Because sufficient data on incidence experience are often not available, the pricing of life insurance products is sometimes based on the mortality rates in population life tables. Thus, we sought to explore whether the mortality rates of the population with insurance policies differ significantly from those of the individuals without insurance policies.

Also, the life insurance products in Taiwan can be classified into three groups: term life, endowment, and whole life products. Endowment products are the most popular and are probably the most distinct attribute of Taiwan as compared to other countries with regard to life insurance. Table 1 lists the numbers of policies issued between 1972 and 2008. Surprisingly, term life products only account for approximately 8% of policies. The mortality risk levels of individuals with these types of insurance products are likely to be different due to factors such as the coverage term, return on principal, and benefit amounts. However, the pricing for these products is based on a single experience life table[3], which possibly mixes up groups with different risk levels.

Table 1. Taiwan insurance policies (1972~2008)

Type	No. of Policies	%
Term Life	4,268,921	8.4%
Endowment	24,132,752	47.3%
Whole Life	22,610,097	44.3%

In this study, we used the experience data from Taiwan's insurance companies to

---

[2] This is defined as the "Ratio of Insurance Coverage" in the annual report by the Taiwan Insurance Institute (http://www.iiroc.org.tw/report_test/1010/PDF1010_2009.pdf ; data retrieved on August 13, 2010). The proportion of people who never purchased life insurance products was 33.44％ at the end of 2008.

[3] The experience life tables used in Taiwan are known as the Taiwan Standard Ordinary Experience Mortality Tables (TSO). The life insurance industry is currently using the 4th TSO or 2002 TSO.

explore the mortality profiles associated with life insurance. We will introduce the experience data on Taiwan in the next section. The primary objective of this manuscript is to explore whether there are risk factors related to mortality rates other than age, gender, and the requirement of health exam (or health exam). The secondary objective is to compare the annual mortality improvement levels in the populations with and without life insurance. However, due to a lack of risk factor information, we cannot evaluate the risk factors for the population without life insurance. It is only possible to estimate and compare the annual reduction rates in mortality with respect to age and gender using the Lee-Carter model. These two objectives are covered in Sections 3 and 4. The discussion of this study and related issues is given in Section 5.

2. DATA DESCRIPTION

In this study, we analyzed the incidence data from life insurance companies in Taiwan for the years 1972~2008 (27 years of data). However, we only used the new policies issued in 1972~2008 because of data availability issues and omitted those policies issued before 1972. The data were collected by the Taiwan Insurance Institute (TII) and cover all life insurance companies in Taiwan[4]. There are three types of insurance policies included in the study: term life, endowment, and whole life.

The experience data include seven other factors that may be correlated with mortality rates in addition to the policy type: age, gender, health exam, principal repayment, amount of benefits, and insurance company size. We will focus on exploring whether mortality rates are correlated with these factors. Age, gender, and health exam are three well-known factors that are highly correlated with mortality

---

[4] The experience data were stored by the Insurance Agency Association of the Republic of China (CIAA) before 2007, and TII has been in charge of the data since 2007. TII now maintains all of the experience data available from 1972 until the present.

rates. Generally speaking, the insured who are younger females and have health exams have lower mortality rates. In the following paragraphs, we will address the following factors: principal repayment, benefit amount, and insurance company size.

The option of principal repayment is another major attribute of many Taiwan life insurance products. This option makes insurance products similar to investments or savings, which may be why this option is very popular in Taiwan. A term life policy will behave like an endowment policy if the percentage of principal repayment is high. Similarly, a whole life policy will behave like an annuity policy under these circumstances. Heuristically speaking, it is natural to expect that insured individuals who have policies with principal repayment will have lower mortality rates.

Also, the benefit amounts are relatively low compared to the gross national product (GNP) per capita in Taiwan. According to the estimate by the Directorate-General of Budget, Accounting and Statistics (DGBAS), Executive Yuan, the GNP per capita of Taiwan in 2009 was $16,997, which is approximately 0.5 million New Taiwan (NT) dollars. The average benefit amount for life insurance products is also approximately 0.5 million NT dollars, which indicates that under-insurance is an issue in Taiwan. The benefit amounts are separated into 3 groups by TII: < 0.5 million, 0.5~1.0 million, and > 1.0 million. A small proportion of insurance products also require health exams[5] and are associated with low benefit amounts. Less than 10% of policies include a health exam, and many of them are not mandatory. Because most policies do not require a health exam, it should be interesting to determine whether this phenomenon induces a moral hazard.

The experience data came from 28 insurance companies, which we separated into three groups (small, middle, and large) according to the number of policies issued

---

[5] The health exam usually covers general items, including height, weight, blood pressure, and pulse. If the benefit amount is high, sometimes blood test and urine test are required.

by each company. There were nine companies in the small group, ten in the middle group, and nine in the large group to ensure an even distribution. The companies in the small group do not offer more than 100,000 policies, and the companies in the large group do not offer policies of less than 400,000. The total number of policies in the small, middle, and large company groups are 485,105; 1,936,050; and 24,555,354, respectively. Because the proportion of individuals in the small company group is less than 2%, we will focus on comparing the mid-sized and large companies. Because the large companies have a larger capacity (or tolerance) and more marketing choices, the mortality rates of customers at the large companies are likely to be higher.

Table 2. Summary of policy numbers derived from Taiwan female insurance data

Risk Factor		Company Size		
		Small	Middle	Large
Health Exam	No	440,407	2,504,019	20,263,883
	Yes	27,955	177,872	2,015,745
Principal Repayment	No	176,093	1,194,873	5,804,234
	Yes	292,269	1,487,018	16,475,394
Benefit Amount	< 0.5 M	192,682	1,217,410	13,596,801
	0.5~1.0 M	108,728	588,675	5,021,068
	> 1.0 M	166,952	875,806	3,661,759

Note: The benefit amount of 1.0 M is one million New Taiwan Dollars $\approx$ $33,000 U.S.

Tables 2 and 3 provide the summary statistics for the experience data according to company size. It seems that companies of different sizes have their own marketing strategies. For example, small companies have fewer policies and offer small benefit amounts, whereas large companies have fewer policies with principal repayment. Overall, most policies have very low benefits, and most policies do not require health exams. Interestingly, more than 70% of policies include principal repayment. If we

exclude the endowment products (47.3% in Table 1), we can analyze the term life and whole life products exclusively. The finding that emerges is that approximately half of the term life and whole life products include principal repayment, which is a very high percentage.

Table 3. Summary of policy numbers derived from Taiwan male insurance data

Risk Factor		Company Size		
		Small	Middle	Large
Health Exam	No	443,312	2,415,117	20,312,461
	Yes	26,578	200,704	2,184,334
Principal Repayment	No	182,588	1,173,166	6,153,976
	Yes	287,302	1,442,655	16,342,819
Benefit Amount	< 0.5 M	178,209	1,117,410	12,844,392
	0.5~1.0 M	114,953	585,970	5,421,639
	> 1.0 M	176,728	912,441	4,230,764

Note: The benefit amount of 1.0 M is one million New Taiwan Dollars ≈ $33,000 U.S.

We shall continue exploring the experience data in the next two sections. We first determine whether there are mortality-related factors in the next section and then compare the mortality rates in the population table to those in the experience table.

3. EMPIRICAL ANALYSIS

Because the population of Taiwan is not large (approximately 23 million), the observed mortality rates for each age group will fluctuate significantly between two consecutive years. To reduce variations, the experience data were partitioned into 5-age groups for each year. Also, the youngest age group is 0~14 (ages 0 to 14 years), and the highest age group is 80+ (ages 80 years and over). This makes it possible to accumulate sufficient claim data. We found that there are four factors related to

mortality rates: principal repayment, company size, health exam, and benefit amount. We shall summarize the major findings in this order.

The mortality rates for term life, endowment, and whole life policies are very similar, but there are obvious differences if these policies are separated based on whether they include principal repayment. We only used the data on term life and whole life policies in analyzing the effect of principal repayment because, by definition, an endowment policy must include principal repayment. Because the nature of principal repayment is similar to that of an annuity and/or endowment, i.e., it offers payment upon survival, it is not a surprise that mortality rates are smaller for policies with principal repayment. We shall demonstrate the case of male mortality rates as shown in Figure 2. The male mortality rates associated with the term life policies with principal repayment are the lowest in all groups, and those associated with the term life policies without principal repayment are the highest. The differences are less obvious for the whole life policies, and the mortality rates under the condition of principal repayment are still lower.
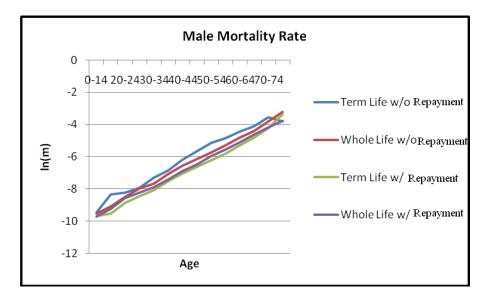

Figure 2. Mortality comparison for principal repayment (Taiwan Male).

An additional comparison can be made using mortality ratios (Figure 3). On average, the difference between the male mortality levels based on whether principal repayment is included is approximately 50% for the term life and 20% for the whole life policies. This is a very significant difference in the pure premiums of these policies, especially for the term life policies, even after considering the interest rate. The difference between the pure premiums for the term life policies when principal repayment is included versus when it is not is approximately 50%. The pure premium difference for the whole life policies is sensitive to the interest rate, of which it is a decreasing function.
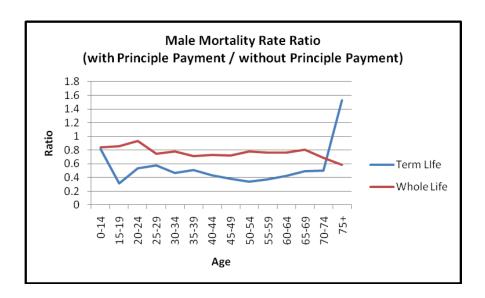

Figure 3. The mortality ratio for principal repayment (Taiwan Male).

In analyzing company size, we first looked at the summary statistics (Table 4). Because the small company group provides less than 2% of the policies, we focused on comparing the mid- and large-sized companies. For both males and females, the mid-sized companies target on the whole life policies (about 65.6%), whereas approximately 50% of the policies offered by the large companies are endowment policies. On the other hand, in mid-sized companies, fewer than 1% of the policies are

term life policies, and the corresponding figure for large companies is approximately 9%.

Table 4. Summary of policy numbers with reference to company size.

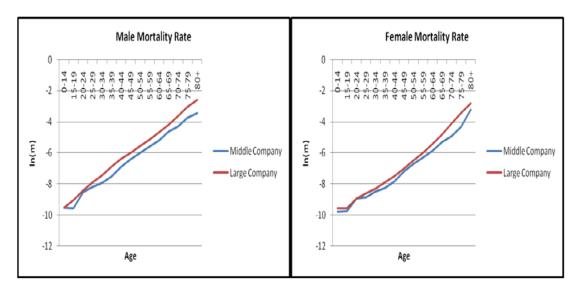| Gender	Company Size	Term Life	Endowment	Whole Life
Male	Large-sized Company	1,584,231	11,352,337	9,560,227
	Mid-sized Company	239,357	654,538	1,721,926
Female	Large-sized Company	2,165,901	10,952,936	9,160,791
	Middle-sized Company	223,935	712,346	1,745,610

Figure 4. Mortality comparison based on company size (Taiwan Male).

The overall mortality comparisons based on company size are presented in Figure 4. The mortality rates presented for mid-sized companies are generally lower in all age groups, and the difference is more obvious for males. One possible interpretation is that mid-sized companies are less tolerant of losses and thus are more risk-sensitive. In addition, the average cost of issuing a new policy is likely to be higher for mid-sized companies. The lower mortality rates would provide a better

11

survival opportunity for mid-sized companies.

As expected, the mortality rates associated with plans that include health exams are lower (details of these findings will not be presented). The benefit amounts were divided into three categories: less than $0.5 million NT dollars, $0.5~1.0 million NT dollars, and more than $1 million NT dollars. For term life insurance, the policies with benefit amounts of less than 0.5 million NT dollars have the lowest mortality rates, whereas those with benefit amounts of more than 1.0 millions NT dollars have the highest mortality rates (Figure 5). The patterns reverse for endowment insurance, namely the mortality rates are the lowest for benefit amounts greater than 1.0 million NT dollars. This important finding implies that insurance companies should use different mortality rates for pricing according to their benefit amounts to avoid biased selection. We can use this information to further differentiate mortality risk (for term life policies) and seek a better way to address longevity risk (endowment).
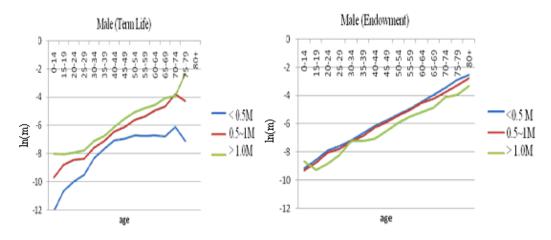

Figure 5. Mortality comparison of benefit amounts (Taiwan Male).

In addition to using graphs to show the different mortality rates with respect to the risk factors analyzed, we also conducted logistic regression to demonstrate the differences. Table 5 shows the regression results. As expected, all of the coefficients

of the risk factors are significant. It should be noted that except for the continuous variable "age," all variables (including the dependent variable, 0/1 indicating survival/death) are indicator variables, with 0/1 indicating No/Yes. The variable "benefit amount" is defined as 1 if it is larger than 1 million, and the variable "company size" is 1 for large companies. Comparing the effect of the risk factors principal repayment, company size, and benefit amount, we found that the effect of company size is the largest and that the effect of principal repayment is the smallest. Still, all three factors have a smaller impact on mortality risk than the factor gender. However, their effects are greater than the influence of the health exam factor, which suggests that including these risk factors may help to reduce the possibility of moral hazard or biased selection.

Table 5. Summary of logistic regression for mortality rates

Predictor	Coef	SE	Z	P-value	Odds Ratio	95% C.I.	
						Lower	Upper
Constant	-9.0498	.0166	-545.11	<.0001			
Gender	-.8149	.0028	-286.56	<.0001	.44	.44	.45
Age	.0726	.0004	191.45	<.0001	1.08	1.07	1.08
Age^2	.000042	.0000036	11.55	<.0001	1.00	1.00	1.00
Health Exam	-.0594	.0034	-17.66	<.0001	.94	.94	.95
Principal Repayment	-.1653	.0030	-54.46	<.0001	.85	.84	.85
Benefit Amount	-0.2357	.0073	-32.30	<.0001	.79	.78	.80
Company Size	.2879	.0057	50.57	<.0001	1.33	1.32	1.35

In this section, we found that four factors (principal repayment, company size, health exam, and benefit amount) are highly correlated with mortality risk. Some of

the results are quite unique, and further study should be undertaken to determine what causes differences in mortality risk. Also, the level of mortality risk is very significant, which suggests that insurance companies in Taiwan should pay more attention to pricing life insurance products. Using a single experience life table (TSO) is not appropriate for calculating pure premiums, and the insurance companies need to take into account the appropriate risks to avoid risk aversion.

4. MORTALITY IMPROVEMENT

In this section, we will continue our empirical analysis by comparing the mortality rates based on population data to those based on experience data using the Lee-Carter model, which was proposed by Lee and Carter (1992). According to this model, the central mortality rate $m_{x,t}$ should be consistent with the following equation

$$\ln\left(m_{x,t}\right) = \alpha_x + \beta_x \kappa_t + \varepsilon_{x,t} , \tag{1}$$

where parameter α_x describes the average age-specific mortality, κ_t represents the improvement in the general mortality level over time, and the decline in mortality at age x is captured by β_x. As in the previous section, the data are presented in 5-year groups, but we aggregated 3 years of data when using the Lee-Carter model to acquire more observations.

The coefficients α_x and β_x have similar values for the entire population of Taiwan and for the people purchasing insurance products. However, the mortality improvement over time, which can be expressed in terms of κ_t, behaves quite differently in these two groups. As shown in Figure 6, the slope of κ_t is steeper for the people purchasing insurance products, which indicates obvious mortality

improvement. Because the life insurance industry is less than 40 years old in Taiwan

(it was started in the 1970s), relying on population data to develop experience rates is

sometimes unavoidable. However, based on our findings, it seems that this procedure

must be handled with care because the level of mortality improvement is likely to be

different. If the annuity table is constructed using the population data, the premiums
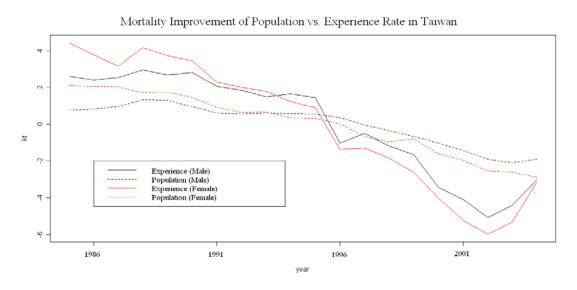
will be underestimated.

Figure 6. Mortality improvement of the population vs. experience data in Taiwan.

In addition to obtaining the annual improvement rate, we also determined the

improvement rate of each age group. Figure 7 compares the annual improvement rates

of the 5-age groups (or $\beta_x \kappa_t$ in Equation (1)). For both males and females, the

differences between the improvement rates based on the population and experience

data are larger for the younger age groups. The gaps decrease as age increases, and

there is no difference among people aged 70 years and above, in which the annual

improvement is about 2% (or in which there is a 2% mortality reduction rate). The

females show a greater mortality improvement than the males, and the rates are higher

for the younger groups. To use the Lee-Carter model in Figures 6 and 7, we required

15

complete data for all age groups. However, because there were not enough data for the 20s and 70s age groups from the 1970s and early 1980s, we used the data from after 1984 with the Lee-Carter model.
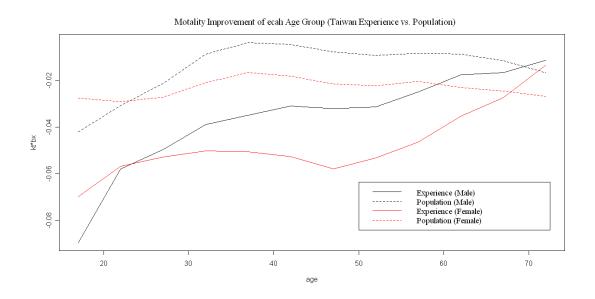

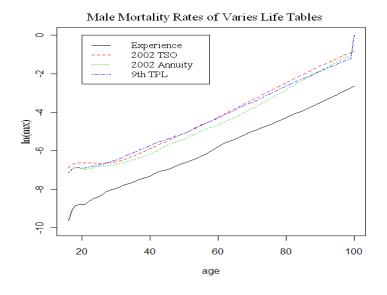Figure 7. Mortality improvement of the population vs. experience data (by age group).

Figure 8. Male mortality rates of various life tables.

In the rest of this section, we will evaluate the pricing of insurance products

16

using the experience data based on the results obtained from the Lee-Carter model. More specifically, we will calculate the pure premiums paid for whole life, annuity, and endowment products and will determine the difference between the figures obtained using the regular period life tables (without considering mortality improvement) and the cohort life table (considering mortality improvement). The period life tables considered are the 2002 TSO (also known as the 4th Taiwan Standard Ordinary Experience Mortality Table), the 2002 Annuity Table, and the 1999-2001 Taiwan Complete Life Table (or 9th Taiwan Period Life Table; 9th TPL).

Currently, the 2002 TSO is still used to calculate the premium and reserves for life insurance products in Taiwan even though the mortality rates are already out of date. Other countries in Asia, such as Japan and South Korea, also face a similar situation. Next, to determine the amount of mispricing (over-estimation) that occurs in practice, we compare the premiums calculated using the official life table (2002 TSO) and those calculated using cohort mortality (Lee-Carter model). The male mortality rates (as presented in Figure 8) are used to demonstrate the differences between the results obtained using these life tables. The experience data (data period: 2004-2008) apparently yield the smallest mortality rates, and other life tables yield similar results. Note that the 2002 annuity table was used to price the annuity products in Taiwan.

Because neither the 2002 TSO nor the 9th TPL includes mortality improvement, the pure premiums of life insurance products will be overestimated. To account for the overestimation, usually insurance companies in Taiwan would adapt lower mortality rates. However, even 80% and 90% of the 2002 TSO mortality rates are used for the premium calculation, the overestimation cannot be resolved entirely. Table 6 lists the overestimation percentages for the whole life policies at different issue ages when these period tables are compared to the cohort life table based on the experience data.

The interest rate is assumed to be 3%, and it is assumed that no individuals will survive beyond the age of 100.

Table 6. Percentages of premium overestimations in whole life policies

Issue Age			20	30	40	50
2002 TSO	Male	100%	54.6%	47.0%	39.4%	31.7%
		90%	49.1%	42.1%	35.0%	27.9%
		80%	43.2%	36.7%	30.2%	23.7%
	Female	100%	90.6%	86.7%	81.6%	75.1%
		90%	83.8%	80.3%	75.6%	69.6%
		80%	76.1%	72.9%	68.6%	63.2%
9th TPL	Male		54.1%	46.6%	38.5%	30.1%
	Female		90.6%	86.8%	81.7%	75.2%

The overestimates are more obvious for females as in Figure 7 and are larger for younger age groups (up to 90%). Even when a policy is issued for a 40-year-old man, the overestimate is at least 30%. (The differences will be even larger for the term life policies according to our calculations.) Because the overestimate of the pure premium is non-negligible, many life insurance companies return the over-paid premium if the observed mortality rates are lower than a pre-defined value (i.e., in participating policies or profit policies).

We calculated the pure premiums for annuity products as well, considering immediate and deferred annuity. Again, the interest rate is 3%, and the ultimate age is 100. As shown in Tables 7 and 8, the underestimates are significant (more so for females). For example, Table 8 shows that the underestimate by insurance companies in Taiwan is currently 63.2% for a 20-year-deferred whole life annuity policy issued to a female of age 40.

Table 7. Premium underestimation percentages for annuity policies (males)

Deferred period/Age		20	30	40	50
2002 Annuity	0	8.2%	9.5%	10.9%	12.0%
	10	26.7%	27.9%	29.3%	30.6%
	20	33.3%	36.6%	41.6%	49.8%
9th TPL	0	10.9%	13.4%	16.1%	18.8%
	10	35.1%	38.4%	42.1%	46.9%
	20	44.4%	51.2%	61.3%	77.9%

Table 8. Premium underestimation percentages for annuity policies (females)

Deferred period/Age		20	30	40	50
2002 Annuity	0	8.8%	11.7%	15.7%	21.3%
	10	32.4%	37.7%	45.2%	56.6%
	20	39.8%	48.7%	63.2%	90.3%
9th TPL	0	9.9%	13.3%	18.0%	24.5%
	10	36.2%	42.5%	51.5%	65.3%
	20	44.8%	55.5%	72.9%	106.1%

Table 6 indicates that insurance companies will profit from issuing a life insurance policy because they will overestimate the premium. However, an endowment policy is a combination of the pure life and pure endowment policies. Insurance companies overestimate the premiums for the pure life portion of the coverage and underestimate the pure endowment portion. Figure 9 shows the pricing differences between endowment policies with 10% annual principal repayment calculated using the 2002 TSO mortality rates and the experience rates with mortality improvement. In Figures 9 and 10, the X-axis (duration) is the policy period, the Y-axis is the issuing age of the insured person, and the contour values are the under-/overestimates of the pure premiums. Positive/negative values indicate that the insurance companies over-/underestimate pure premiums. For example, Taiwan's insurance companies can overestimate more than 30% of the pure premium for a 10-year endowment policy issued to a female of age 20 and underestimate more than

30% of the pure premium for a 30-year endowment policy issued to a female of age 20.
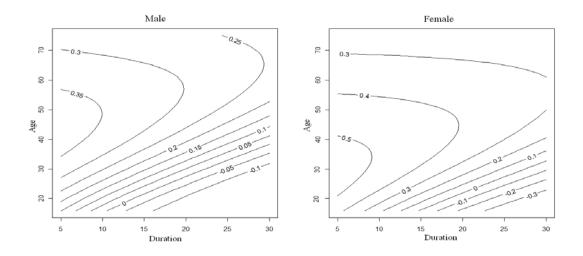

Figure 9. Pricing differences for endowment policies (with 10% annual principal repayment) (2002 TSO vs. experience).
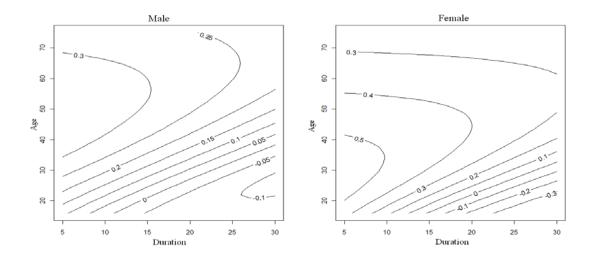

Figure 10. Pricing differences for endowment policies (with 10% annual principal repayment) (9th TPL vs. experience).

Because the endowment policy is categorized as a life insurance policy, insurance companies may think that they will always make a profit from life insurance policies due to mortality improvement. On the contrary, however, insurance companies may also experience a deficit of more than 30% if they issue endowment

policies. This is an important finding, especially for Taiwan, because endowment policies are very popular in Taiwan's insurance market. The results are similar if the premiums are calculated based on the 9th TPL and Taiwan experience rates (Figure 10).

5. DISCUSSION

A continuing mortality improvement and, therefore, an increasing life expectancy are evident in many countries, and many believe that life expectancies will continue to increase. This increase has changed our living arrangements, especially after retirement, and pension products are becoming more popular. However, because mortality rates are likely to decline continuously in the future, annuity pricing is very difficult. This finding is especially true of countries without sufficient historical data. In this study, we used the experience data from Taiwan insurance companies to explore the mortality profiles of experience rates and to investigate potential problems.

The primary objective of this study was to identify mortality risk-related factors and to include these factors in the premium calculation process to avoid moral hazard and biased selection. Our findings indicate that in addition to age, gender, and health exam, there are three new mortality risk factors: principal repayment, benefit amount, and insurance company size. However, contrary to our expectations, the mortality rates associated with the three types of life insurance policies (term life, endowment, and whole life) do not differ significantly. Instead, the new risk factors are more correlated with mortality rates than with policy type.

Principal repayment probably plays a rather unique role in Taiwan. Policies that include this option seem to be associated with lower mortality rates. Also, mid-sized

companies report lower mortality rates than do large companies. Policies that include health exams and larger benefit amounts are also associated with lower mortality rates. These results suggest that consumer behaviors in Taiwan might be different than in other countries. (For example, term life policies are not popular in Taiwan.) Insurance companies should use two different pricing bases for mortality rates to avoid moral hazard and to protect policyholder rights. The risk factors are not likely to be the same in different countries, and we suggest a full exploration of the experience data from every country.

The secondary objective of this study was to compare the current mortality rates and mortality improvement obtained using the experience data and the whole population data in Taiwan. The current experience mortality rates are much lower and also exhibit better mortality improvement. The differences in improvement are especially significant for the female groups and the younger age groups, whereas they are not as obvious for the older age groups. We use the premium of whole life policy as a demonstration. The mortality improvements of the experience data are significantly different from those of the population data (Table 9). Because the degree of mortality improvement is very significant in Taiwan, use of the traditional period life table to calculate pure premiums for insurance policies is no longer advisable. Decreasing mortality rates may cause either overestimated or underestimated pure premium calculations.

Table 9. Premium ratio of experience/population mortality improvement (whole life).

Experience premium / Population premium				
Issue Age	20	30	40	50
Male	82.8%	83.3%	85.6%	88.6%
Female	71.4%	69.4%	67.9%	66.9%

For example, Figure 9 shows that Taiwan's insurance companies can either

overestimate or underestimate pure premiums by more than 30% for endowment policies (with 10% annual principal repayment) issued to females of age 20 depending on the duration of the policy. This is an important finding. Endowment policies are also very sensitive to mortality changes. These results contradict those of past work and suggest that the mortality improvement may cause undercharging in premium calculations not only for annuity products but also for life insurance products. Both the governments and life insurance companies must work harder to address longevity risk and the decreasing mortality rates.

In addition to these findings, we also identified other serious problems in Taiwan's life insurance industry. The history of life insurance in Taiwan is not long, and the experience data have not been fully explored. Very few insurance companies have their own experience tables, and everyone relies on the same experience tables (2002 TSO and 2002 Annuity Table) except for the largest companies. Therefore, it is difficult for small- and mid-sized companies to compete with large companies based on the same mortality rates. As shown in Figure 4, the mid-sized companies have lower mortality rates, which allow them to compete with the large companies.

REFERENCES

Bell, W.R. (1997) 'Comparing and Assessing Time Series Methods for Forecasting Age-Specific Fertility and Mortality Rates'. *Journal of Official Statistics* **13**(3): 279-303.

Heligman, L. and Pollard, J.H. (1980) 'The Age Pattern of Mortality', *Journal of the Institute of Actuaries* **107**: 49-75.

Huang, H., Yue, C.J., and Yang, S.S. (2008) 'An Empirical Study of Stochastic Mortality Models', *Asia-Pacific Journal of Risk and Insurance* **3**(1): 150-164.

Human Mortality Database, http://www.mortality.org.

Lee, R.D. (2000) 'The Lee-Carter Method for Forecasting Mortality with Various Extensions and Applications', *North American Actuarial Journal* **4**: 80-93.

Lee, R.D., and Carter, L.R. (1992) 'Modeling and Forecasting U.S. Mortality', *Journal of the American Statistical Association* **87**: 659-671.

Wilmoth, J. (1996) 'Mortality Projections for Japan: A Comparison of Four Methods', in G. Caselli and A.D. Lopez (eds.) *Health and Mortality Among Elderly Populations*, New York: Oxford University Press, pp. 266-287.

Yang, S.S., Yue, C.J., and Huang, H. (2010) 'Modeling Longevity Risk using a Principal Component Approach: A Comparison with Existing Stochastic Mortality Models', *Insurance: Mathematics and Economics* **46**(1), 254-270.