

Pricing Mechanism Effects of Switching to New Life Table in China - Based on Analysis of Basic Life Insurance Products

Hualin Zhou

School of Finance, Yunnan University of Finance and Economics, Yunnan, China, and

Weichen Sang *

School of Finance, Yunnan University of Finance and Economics, Yunnan, China

Abstract

Life tables are a critical basis for actuarial pricing in life insurance. Following the switch to Life Table-2023 in China, prices for life insurance products insuring mortality risk have generally decreased to varying degrees, while prices for products covering survival risk have increased to different extents. Prices of term life insurance product have seen the largest decrease, approaching 50%, whereas prices of deferred whole life annuity product have risen the highest by nearly 30%. The price increase for various deferred annuity insurance products is higher than for non-deferred life insurance products. The reduction in assumed interest rate has a greater impact on the prices of cash value life insurance products than the decrease in mortality rates. Even small changes in assumed interest rate can cause significant price volatility in cash value life insurance products. The prices of high-leverage life insurance products, such as term life insurance products, are more affected by changes in mortality rates. The switch to Life Table-2023 is expected to exert a significant price leverage effect on various life insurance products. However, the actual price changes of life insurance products are influenced by multiple factors, and it remains uncertain whether these pricing mechanism effects will result in substantial market impacts. The use of region-specific life tables might lead to some cross-regional consumption, although it is unlikely to become a mainstream market trend. In the future, the cost of managing retirement risks in China is expected to rise, exacerbating the burden on social retirement systems.

Keywords: Life Table; Retirement Risk Management; Actuarial Assumptions; Actuarial Mathematics in Life Insurance; Mortality Rate

* Corresponding author. E-mail address: 819638453@qq.com.

Supported by national natural science foundation: research on longevity risk management in China from the perspective of material production (grant number: 72064040).

I. Introduction

Since the resumption of life insurance operations in China in 1982, China Life Insurance Industry Experience Life Tables[§] (abbreviated as ‘life tables’) have undergone continuous improvement and refinement. These tables, designed to support the development of China's life insurance industry, include Life Table-1993 (‘China Life Insurance Industry Experience Life Table (1990–1993)’), Life Table-2003 (‘China Life Insurance Industry Experience Life Table (2000–2003)’), and Life Table-2013 (‘China Life Insurance Industry Experience Life Table (2010–2013)’). Recently, based on data from 2018 to 2021, Life Table-2023 (‘China Life Insurance Industry Experience Life Table (2020–2023)’), informally known as the “Fourth Edition Life Table”) has been compiled. Final refinements and adjustments are currently being made based on feedback from the ‘Draft for Comments on Life Table-2023’, with the official implementation of Life Table-2023 forthcoming. The life table is a critical foundation for life insurance actuarial pricing. Life insurance serves multiple functions, combining risk protection with financial attributes. It is an essential financial tool for households or individuals to manage life risks and to preserve and grow wealth. Basic life insurance products^{**} serve as the foundation and basis for designing insurance liability clauses in the life insurance industry. By integrating the liability clauses of certain basic life insurance products—such as merging the liability clauses of term life insurance or whole life insurance with those of annuity insurance—or combining the liability clauses of basic life insurance products with health-related clauses (e.g., merging whole life insurance with critical illness insurance), it is possible to develop and design various life insurance products that achieve comprehensive personal risk management. Additionally, by adding investment features to traditional basic life insurance products, investment-linked life insurance products can be developed. The pricing of the risk protection services in these new types of life insurance products remains consistent with actuarial principles in life insurance.

There is limited analysis in the international literature regarding the pricing effects of life table transitions. Some studies have found that the adoption of a new life table can impact valuation schemes (altering employer incentive structures), affect pension fund premium rates and the distribution of insurance amounts, and increase the costs associated with traditional Defined Benefit (DB) pension plans (Kilgour, 2016). An increase in adult mortality rates leads to a decrease in the cost of annuity products, while simultaneously increasing the cost of risk protection products (Lledó & Atance, 2023). The majority of the literature focuses on analyzing the methodologies used to estimate mortality rates within life tables (Lynch & Brown, 2005; Coviello et al, 2015; Bremberg, 2017; Muniz, 2020). Demographic and financial factors are the primary risk drivers for pension funds. In a low-interest-rate market environment, demographic factors become a significant source of risk for annuity insurance (Rabitti & Borgonovo, 2020). When both interest rate and mortality risks are uncertain, financial risk emerges as the predominant risk driver for pension funds. Some domestic studies have analyzed the impact of life table adjustments on mortality rates, while others have explored the effects of these adjustments on the pricing of new life insurance products, typically focusing on changes in the prices of specific basic life insurance products. However, there is a lack of comprehensive analysis regarding the pricing mechanisms of various basic life insurance products. The functional roles of different basic life insurance products in managing life risks vary significantly, leading to considerable differences in how their prices are affected by changes in

[§] Mortality-Only.

^{**} Single-risk life insurance products, based on variations in life insurance actuarial pricing rules, can be categorized into several types, including term life insurance, whole life insurance, endowment insurance, increasing life insurance, term survival annuities (both non-deferred and deferred), whole life survival annuities (both non-deferred and deferred), and increasing annuities.

life tables. Some domestic studies on annuity insurance do not adequately distinguish between deferred and non-deferred payment annuities. Deferred annuities are more strongly associated with retirement risk management, while non-deferred annuities are often used as wealth management tools. The functional roles of these two types of annuities differ significantly, and their prices are affected differently by changes in life tables. Therefore, the price changes in one type of annuity cannot represent the overall price effects. Although life insurance products in practice are highly diverse, the pricing effects of life table changes on the basic life insurance products within insurance liability clauses adhere to life insurance actuarial principles. In China, the transition to a new life table is often accompanied by adjustments in life insurance premium policies. Therefore, when analyzing the impact on pricing mechanisms, it is essential to consider the combined effects of both premium policy adjustments and life table changes. There is a certain degree of risk hedging between survival risk^{††} and mortality risk insurance, complicating the achievement of effective hedging (Olivieri, 2001; Blake and Burrows, 2001; Cowley and Cummins, 2005; Gründl et al, 2006). The new life table adjustment has little impact on insurance premium rates, but a substantial reduction in liability reserves will increase the solvency ratio of insurance companies (Li, 2006)). Several studies have examined the impact of life table improvements on the pure risk premium of annuity insurance products under stochastic mortality scenarios. The findings indicate that the pure risk premium for annuity insurance products rises to varying extents across different age cohorts, with the most significant increases observed in younger age groups. The later the purchase, the more pronounced the increase in premiums (Wang and Qian, 2008). Some studies have analyzed the pricing effects of life table transitions. Their findings indicate that premiums for term life insurance and endowment insurance products decreased, with the changes being less pronounced for males compared to females. Premium adjustments for whole life insurance products were relatively minor, while premiums for annuity insurance products increased (Zhang, 2007; Chen and Zhu, 2007; Ma, 2018). These studies collectively indicate that life table transitions have varying impacts on the prices of life insurance products. Specifically, the prices of life insurance products covering mortality risk decreased. The prices of term life insurance, whole life insurance, and endowment insurance products covering mortality risk were affected differently by life table adjustments. In contrast, the prices of life insurance products covering survival risk increased, resulting in higher costs for pension risk management. Some studies have compared the differences between Life Table-2013 and Japanese life table based on the compilation process of Japan's 2018 life table. These studies, drawing on Japan's life table methodology, have provided recommendations on the choice of elderly extrapolation methods, the selection of starting and maximum ages for extrapolation, and the determination of ultimate mortality rates. However, they did not analyze the impact of life table transitions on the pricing of new life insurance products (Sun, 2023).

Since 2020, China's population aging situation has intensified, leading to increased pressure on longevity risk management. Life Table-2023 is the first set of life tables released after the country entered this intensified stage of population aging. Compared to Life Table-2013, the mortality rates in Life Table-2023 have been significantly reduced once again. Notably, the mortality rates for the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) are listed separately, with rates lower than the national average. This indicates a worsening degree of population aging in China, and it suggests that the GBA faces even more severe aging challenges. Insurance is one of the components of the third pillar of pensions system (Zhou, 2023). The transition to a new life table will influence the consumption of commercial pension insurance through its impact on pricing mechanisms. This, in turn, will affect the role of commercial insurance within the third pillar of the pension system. Since 2017, China has

^{††} Survival risk refers to the risk of having no source of income due to an excessively long life span.

implemented a stringent regulatory environment, and the impact of the COVID-20 pandemic after 2020 has further intensified the situation. In 2023, China urgently reduced the evaluation premium rate for life insurance^{††}. In September 2024, the life insurance evaluation interest rate is set to be reduced again. The life insurance industry is currently facing a challenging development environment. The evaluation interest rate is one of the key factors influencing life insurance actuarial pricing. When the evaluation premium rate is adjusted, the assumed interest rate will also change accordingly. The transition to Life Table-2023 was accompanied by adjustments to the assumed interest rate, leading to changes in two core factors of life insurance actuarial pricing. As a result, the pricing leverage mechanism for various basic life insurance products functions differently, affecting both the development of the life insurance industry and the costs of social management. Therefore, it is crucial to quantify the pricing leverage effects of both the reduction in mortality rates and the decrease in assumed interest rate. Evaluating the impact of these pricing mechanisms is especially important for understanding their influence on the development of the life insurance industry and the broader implications for social management.

The main innovations of this paper are as follows: First, by using mortality data published by the industry, life tables for actuarial pricing in life insurance were compiled. These tables were then used to calculate the price changes for various basic life insurance products, thereby measuring the changes in the cost of life risk management or wealth management. Second, the impact of regional differences in life tables on the pricing of basic life insurance products was analyzed. This included a comparison of life insurance product prices in the GBA with those nationwide, thereby measuring the price leverage effects of regional differences in life tables. Third, the effects of adjustments in assumed interest rate and assumed mortality rate on the pricing of various basic life insurance products were compared. This analysis evaluated the differing impacts of these two core pricing factors on product pricing.

II. New changes in Life Table-2023

2.1 Diversification of the life table contents

Compared to previous versions, Life Table-2023 has significantly expanded and altered its contents (Table 1). It includes the National Experience Life Table (3 tables), the Greater Bay Area Exclusive Life Table (3 tables), and the Single Life Table (1 table). The content of the life table is now richer and more diversified. Building on the 2013 National Experience Life Table, the new additions include the Greater Bay Area^{§§} Exclusive Life Table and the Single Life Table, designed to meet the regional economic development needs and single life expectancy patterns. This provides industry-standard life tables for pricing such life insurance products, better aligning with the life expectancy patterns of these markets. The national experience life table in Life Table-2023 has also been slightly adjusted compared to Life Table-2013. The non-pension business table 1 is primarily applicable to life insurance products covering death risk, such as term life insurance and whole life insurance. In contrast, the non-pension business table 2 is mainly suitable for life insurance products with relatively lower death and survival risks. In Life Table-2013, the non-pension business table 1 was primarily aimed at life insurance products with high protection leverage, while the non-pension business table 2 was targeted at

^{††} The premium rate policy of life insurance products primarily regulates the setting of evaluation rates for these products. The evaluation rate serves as a crucial basis for assumed interest rate, which represents the expected return rate provided by the insurer to the policyholders. Assumed interest rate is a significant foundation for the actuarial pricing of life insurance products. Therefore, adjustments to the life insurance premium rate policy have a substantial impact on product prices.

^{§§} The life table was formulated using policy and claims data from nine cities in China: Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing.

life insurance products with relatively strong saving functions (Wang et al, 2021). Life Table-2003 and Life Table-1993 were relatively simplified, containing only the non-pension business table (1 table) and the pension business table (1 table).

Table 1 Comparison of the contents of Chinese life insurance industry experience life tables

		2023	2013	2003	1993
National Experience Life Table	Non-Pension Business Table 1 (CL1)	Male & Female	Male & Female	Male & Female	Male & Female
	Non-Pension Business Table 2 (CL2)	Male & Female	Male & Female		
	Pension Business Table (CL3)	Male & Female	Male & Female	Male & Female	Male & Female
The Greater Bay Area Exclusive Life Table	Non-Pension Business Table 1 (CL4)	Male & Female	-	-	-
	Non-Pension Business Table 2 (CL5)	Male & Female	-	-	-
	Pension Business Table (CL6)	Male & Female	-	-	-
Single-Life Entity Life Table	(CL7)	Male & Female	-	-	-

2.2 Average mortality rate decreased by 24.4%

Compared to Life Table-2013, the average mortality rate in Life Table-2023 has further decreased (Table 2). The national average mortality rate^{***} in Life Table-2023 is 24.42% lower than in Life Table-2013, a decrease of 6.21 percentage points more than in the previous table. Male mortality decreased by 22.09%, while female mortality decreased by 26.99%, showing a larger reduction for females. The average mortality rate in the Greater Bay Area exclusive life table is 16.22% lower than the national average, with males 16.66% lower and females 15.80% lower. The larger reduction in the Greater Bay Area is mainly due to a greater decrease in male mortality rates. The mortality rate in Life Table-2013 was lower than in Life Table-2003, but the decrease was less significant. The average mortality rate in Life Table-2013 was 12.94 percentage points lower than in Life Table-2003. Since the national experience life table in Life Table-2023 excludes the Greater Bay Area's lower mortality rates, it may underestimate the decrease in the national experience life table.

Table 2 Decrease in average mortality rate in life table

		Non-Pension Business Table 1		Non-Pension Business Table 2		Pension Business Table		Annual Average		
		male	female	male	female	male	female	male	female	total
2023	Greater Bay Area	16.45%	16.21%	17.32%	15.54%	16.22%	15.66%	16.66%	15.80%	16.22%
	National	23.01%	28.07%	23.22%	30.41%	20.17%	23.03%	22.09%	26.99%	24.42%
2013	National	2.25%	11.41%	29.85%	34.68%	32.65%	42.01%	12.99%	25.52%	18.21%
		23.80%	29.79%	-	-	33.97%	39.08%	28.44%	34.12%	31.15%

Note: The average mortality rate decrease for 2023 is the 2013 rate minus the 2023 rate. The same method is used for other years. For the Greater Bay Area, it is the Greater Bay Area rate in Life Table-2023 minus the national rate in Life Table-2023. (Zhou & Wang 2024)

^{***} average mortality rate $(q_1 \cdots q_w)^{1/w}$. q_i denotes the mortality of aged i . w is the maximum age in life table, it is 105 in Chinese life tables.

2.3 National life expectancy continues to increase, with even higher life expectancy in the Greater Bay Area

From the changes in life expectancy across different versions of life tables, there is a continuous trend of increasing life expectancy in China (Table 3). In Life Table-2023, most life expectancies for both males and females in China exceed 80 years, with female life expectancy in the pension table surpassing 90 years. The average life expectancy for males in the pension table is 85 years, while for females it is 91 years, higher than in non-pension business table 1 and non-pension business table 2. The life expectancy values for both males and females in non-pension business table 1 are the lowest among the three sets, indicating that customers purchasing pension insurance products have a longer life expectancy, while those purchasing death risk protection insurance have a shorter life expectancy, aligning with general life patterns. Life expectancy in the Greater Bay Area is higher than the national average, with female life expectancy in the pension table reaching 92 years. Compared to the national average, the Greater Bay Area faces more severe longevity risk management pressures.

The increase in life expectancy in China shows a decreasing trend. Although life expectancy for both males and females continues to rise, the increments are gradually decreasing with each adjustment, typically made every ten years. In Life Table-2023, life expectancy for males and females increased by 1.83 years and 2.45 years respectively, significantly less than the increase observed in Life Table-2013. Life Table-2003 saw an increase of nearly 5 years. In both Life Table-2023 and Life Table-2013, the increase in life expectancy for males is lower than for females, indicating an expanding trend in male longevity risk, while females face a more severe longevity risk exposure.

Table 3 Life Expectancy in Different Versions of Life Tables

		Non-Pension Business Table 1		Non-Pension Business Table 2		Pension Business Table	
		male	female	male	female	male	female
2023	GBA	79.46	85.76	83.11	88.91	85.86	91.57
2023	national	78.43	84.53	82.08	87.89	84.96	90.58
2013		76.42	81.71	80.35	85.44	83.13	88.13
2003		76.71	80.89	-	-	79.74	83.67
1993		73.64	77.76	-	-	74.91	78.96

III. Factors influencing the pricing of life insurance products

The actuarial pricing of life insurance products is influenced by various factors, such as assumed interest rate, assumed occurrence rate, assumed additional expense rate, and assumed lapse rate. Where assumed interest rate, occurrence rate, and additional expense rate are the three core elements of actuarial pricing for life insurance products. These risk parameters assumed in actuarial pricing of life insurance products are referred to as pricing assumptions (Wang et al, 2021; Zhang, 2004, 2005, 2022).

3.1 Assumed interest rate

The assumed interest rate can be regarded as the future investment return on the premiums paid by the policyholder. It is primarily utilized for the calculation of liability reserves and cash values. The value of assumed interest rate largely hinges on evaluation rate, which is employed in the prospective method to determine liability reserves. The valuation interest rate is a key component of the premium rate policy for life insurance products.

Reference formula of evaluation rate is: $i^p = \min\{r_t, \text{int}\}$. Where int =average investment yield of the insurance industry over the past three years—credit risk—investment risk, is risk-

adjusted average investment return rate of the insurance industry. r_t is determined by market interest rates, and $r_t = r^{floor} + w_1[\min(r, r^{cap}) - r^{floor}] + w_2[\max(r, r^{cap}) - r^{cap}] - c$. Where r is the market benchmark interest rate, r^{cap} and r^{floor} are respectively the upper and lower limits of the market benchmark interest rate, w_1 and w_2 are respectively the weighting coefficients, c serves as the implicit cost of dividends. Benchmark market interest rate r is the 750-day moving average of the 10-year government bond yield, r^{cap} and r^{floor} are set based on the historical experience of the benchmark interest rate and future trends, and is a dynamic value.

In the 'Regulations on Actuarial Standards for Traditional Life Insurance Products' (hereinafter referred to as the 'Actuarial Standards'), insurance companies are required to prudently determine the assumed interest rate when setting premiums for life insurance products with insurance periods exceeding one year. This rate should be based on historical investment returns, reasonable future expectations, and product characteristics. In practice, companies generally adopt a conservative assumed interest rate aligned with their investment yield levels. Assumed interest rates differ across life insurance products based on varying insurance periods, coverage scopes, and risk-sharing mechanisms, leading to distinct trends. For life insurance products sensitive to profit and pricing, a more conservative assumed interest rate is applied. This rate may remain uniform throughout the insurance period or be segmented for different periods.

3.2 Assumed incidence rate

Assumed incidence rate encompasses mortality and critical illness rates. In the 'Actuarial Standards', insurance companies are required to determine these rates based on actual experience data and industry-published life tables, while also prudently considering future trends and changes in risk. For life insurance products covering mortality and survival risks, the mortality rate serves as the incidence rate, whereas health insurance products use disease incidence rates. The value of mortality rates is closely related to life tables, and adjustments to life tables can significant impact assumed mortality rates in the actuarial pricing of life insurance products. According to annex 2 of the 'Solvency Regulatory Rules for Insurance Companies No. 3,' the upper and lower limits of the assumed mortality rates are as follows:

mortality incidence rate = mortality rate in basic life table $\times$ multiplier factor $\times$ underwriting selection factor

The basic life table refers to Life Table-2013 (the fourth set of life tables after switching to Life Table-2023). The underwriting selection factor is determined based on the insurer's experience from the first three policy years and is not subject to upper and lower limits, while for other policy years, it is 1.

3.3 Assumed additional expense rate

Assumed additional expense rate is typically set annually, varying by product and across different insurance companies. The average additional expense rate must not exceed the upper limit specified in the 'Actuarial Standards', when determining this rate, total expenses are first calculated and then allocated to each policy according to specific procedures. This allocation is typically expressed as a fixed amount per policy, a percentage of the sum insured, a percentage of the premium, a percentage of the management fee, a percentage of the claim amount, or a fixed amount per surrender or claim. According to annex 3 of the 'Solvency Regulatory Rules for Insurance Companies No. 3,' the standards for the upper and lower limits of the assumed additional expense rate are set for insurers. It specifies the lower limit standards for the assumed additional expense rates for both main and supplementary insurance based on the categories described by the company.

3. 4 Assumed lapse rate

Assumed lapse rate includes the incidence rates of surrender, policy termination due to non-payment, reduced paid-up policies, and fully paid policies that do not continue as expected. These rates are primarily set based on the insurance company's past experience data and future trends. In practice, they are usually determined according to the type of life insurance products and the policy year. According to annex 4 of the 'Solvency Regulatory Rules for Insurance Companies No. 3,' guidance ranges for lapse rate assumptions are provided.

IV. Empirical Analysis

4.1 Actuarial models of life insurance products

1. Basic Function

In life insurance actuarial pricing, the equilibrium premium principle states that the net single premium is the expected value of the present value of payouts (Bowers and Hickman, 1997; Dickson et al., 2020; Wang et al. 2021). Assume the probability that an insured aged x dies in year $k^{\dagger\dagger\dagger}$ is ${}_k|q_x$. Let sum insured be $b_{k+1} = 1^{\dagger\dagger\dagger}$, assumed interest rate be i , and v be the discount factor ($v = e^{-\delta} = (1+i)^{-1}$, with δ being the force of interest). The discount function is v_{k+1} , and the present value of the payout is $b_{k+1}v_{k+1} = v_{k+1}$. Therefore, the present value of a unit amount payout for whole life insurance products is $Z = v^{-k-1}$, and the present value of a unit amount payout for whole life annuity products is $Y = [1 - v^{-k-1}]/[i/(1+i)]$. The mortality rate in the original life table is q_{0x} , and the mortality rate in the new life table is q_{1x} . Assumed interest rate in the original life table is i_0 , and assumed interest rate in the new life table is i_1 .

2. Conversion Function

When using life tables to calculate premium rates of life insurance products, it is necessary to introduce a conversion function (discrete payment method^{§§§}) to simplify the calculations:

$$D_x = v^x l_x; \quad N_x = \sum_{k=0}^{\infty} D_{x+k}; \quad S_x = \sum_{k=0}^{\infty} N_{x+k} = \sum_{k=0}^{\infty} (k+1)D_{x+k}; \quad C_x = v^{x+1}d_x; \\ M_x = \sum_{k=0}^{\infty} C_{x+k}; \quad R_x = \sum_{k=0}^{\infty} M_{x+k} = \sum_{k=0}^{\infty} (k+1)C_{x+k}$$

Based on the mortality rate data published by the life insurance industry, this paper supplements the necessary variables for life insurance actuarial pricing, including survival probabilities, number of survivors, number of deaths, and so on, then constructs tables of conversion functions. Thus forms a complete life table and conversion function table for life insurance actuarial pricing. The paper measures the changes in pure risk premiums for life insurance products based on these life tables and conversion functions. Using these life tables and conversion function tables, the net single premium for immediate death payment under the uniform distribution assumption can be derived from the net single premium for end-of-year death payment. Similarly, the actuarial present value of survival annuities products with end-of-period payments can be derived from the actuarial present value of survival annuities

^{†††} Where k is whole life expectancy.

^{†††} In life insurance actuarial science, the pure premium for a unit sum insured is typically considered. In practice, because the sum insured often exceeds multiples of a thousand or ten thousand units, even small changes in life insurance product prices can result in significant overall cost changes following adjustments to new life Table.

^{§§§} For example, in life insurance actuarial terms, end-of-year death payments are referred to as discrete, while immediate death payments are referred to as continuous.

products with beginning-of-period payments. The discrete conversion function table is core to life insurance actuarial pricing.

3. Life Insurance Product Covering Mortality Risk

Using whole life insurance products as an example, the net single premium for whole life insurance products with end-of-year death payment is:

$$A_x = E(Z) = \sum_{k=0}^{\infty} v^{k+1} \Pr(K = k) = \sum_{k=0}^{\infty} (1+i)^{-k-1} {}_k|q_x = \sum_{k=0}^{\infty} (1+i)^{-k-1} {}_k p_x q_{x+k} = \sum_{k=0}^{\infty} (1+i)^{-k-1} p_x p_{x+1} \cdots p_{x+k-1} q_{x+k} = \sum_{k=0}^{\infty} (1+i)^{-k-1} (1-q_x) \cdots (1-q_{x+k-1}) q_{x+k} \quad (1)$$

Where A_x is the net single premium for whole life insurance products with end-of-year death payment per unit of sum assured. In the specific calculation process, the conversion function for the net single premium for whole life insurance products with end-of-year death payment per unit of sum assured is: $A_x = M_x/D_x$. The conversion function for the net single premium of whole life insurance products with annually increasing benefits: $(IA)_x = R_x/D_x$, where I represents annual increment.

When assumed interest rate i and other conditions remain unchanged, and the mortality rate in life table is adjusted from q_{0x} to q_{1x} , the change of net single premium for whole life insurance products is given by:

$$\frac{\sum_{k=0}^{\infty} (1+i)^{-k-1} (1-q_{1x}) \cdots (1-q_{1x+k-1}) q_{1x+k} - \sum_{k=0}^{\infty} (1+i)^{-k-1} (1-q_{0x}) \cdots (1-q_{0x+k-1}) q_{0x+k}}{\sum_{k=0}^{\infty} (1+i)^{-k-1} (1-q_{0x}) \cdots (1-q_{0x+k-1}) q_{0x+k}} \quad (2)$$

In life table for actuarial pricing, equation (2) is calculated by $(\frac{M'_x}{D'_x} - \frac{M_x}{D_x}) / (\frac{M_x}{D_x})$, where $A_x = M_x/D_x$ is the net single premium for whole life insurance products with end-of-year death payment per unit of sum assured in original life table. $A'_x = M'_x/D'_x$ is the net single premium for whole life insurance products with end-of-year death payment per unit of sum assured in new life table. In the life table for actuarial pricing, the method for calculating price changes for other life insurance products follows the same approach.

When assumed interest rate is adjusted from i_0 to i_1 , and the mortality rate in life table is adjusted from q_{0x} to q_{1x} , while other conditions remain unchanged, the change of net single premium for whole life insurance products is given by:

$$\frac{\sum_{k=0}^{\infty} (1+i_1)^{-k-1} (1-q_{1x}) \cdots (1-q_{1x+k-1}) q_{1x+k} - \sum_{k=0}^{\infty} (1+i_0)^{-k-1} (1-q_{0x}) \cdots (1-q_{0x+k-1}) q_{0x+k}}{\sum_{k=0}^{\infty} (1+i_0)^{-k-1} (1-q_{0x}) \cdots (1-q_{0x+k-1}) q_{0x+k}} \quad (3)$$

4. Life Insurance Products Covering Longevity Risk

Using whole life survival annuities products as an example, with annuities paid at the beginning of each period, the net single premium for whole life survival annuity products is calculated using present value techniques as follows:

$$\ddot{a}_x = E(Y) = \sum_{K=0}^{\infty} v^K {}_K p_x = \sum_{K=0}^{\infty} (1+i)^{-K} p_x p_{x+1} \cdots p_{x+K-1} = \sum_{K=0}^{\infty} (1+i)^{-K} (1-q_x) \cdots (1-q_{x+K-1}) \quad (4)$$

Where $\ddot{a}_x$ is the actuarial present value of the whole life annuity insurance products with beginning-of-period payments per unit of sum assured. In the specific calculation process, the conversion function for the actuarial present value of whole life annuity insurance products is: $\ddot{a}_x = N_x/D_x$; the conversion function for the actuarial present value of whole life annuity insurance products with annual increments is: $(I\ddot{a})_x = S_x/D_x$.

When assumed interest rate i and other conditions remain unchanged, and the mortality rate in life table is adjusted from q_{0x} to q_{1x} , the change of net single premium for whole life survival annuity products is given by:

$$\frac{\sum_{K=0}^{\infty}(1+i)^{-k}(1-q_{1x})\cdots(1-q_{1x+k-1})-\sum_{K=0}^{\infty}(1+i)^{-k}(1-q_{0x})\cdots(1-q_{0x+k-1})}{\sum_{K=0}^{\infty}(1+i)^{-k}(1-q_{0x})\cdots(1-q_{0x+k-1})} \quad (5)$$

When assumed interest rate is adjusted from i_0 to i_1 , and the mortality rate in life table is adjusted from q_{0x} to q_{1x} , while other conditions remain unchanged, the change of net single premium for whole life survival insurance premium is given by:

$$\frac{\sum_{K=0}^{\infty}(1+i_1)^{-k}(1-q_{1x})\cdots(1-q_{1x+k-1})-\sum_{K=0}^{\infty}(1+i_0)^{-k}(1-q_{0x})\cdots(1-q_{0x+k-1})}{\sum_{K=0}^{\infty}(1+i_0)^{-k}(1-q_{0x})\cdots(1-q_{0x+k-1})} \quad (6)$$

4.2 Calculating Result

In Life Table-2023, CL1 table is compiled based on policies with relatively higher risk. In this paper, when presenting results, the price changes for term life insurance products and whole life insurance products are based solely on calculations using the CL1 table. CL2 table in Life Table-2023 is compiled based on policies with relatively lower death risk. In this paper, when presenting results, the price changes for endowment insurance products are only given based on the calculations using the CL2 table. CL3 table in Life Table-2023 is compiled based on pension policies. In this paper, the price changes for annuity insurance products are calculated based on the CL3 table (Zhang, 2004, 2005, 2022).

1. Only Considering the Impact of the reduction in mortality rates

Table 4 shows that with an assumed interest rate of 3.5% in both Life Table-2023 and Life Table-2013, the prices of life insurance products covering death risk decrease to varying extents when only the reduction in mortality rates is considered. Term life insurance products, which has a higher insurance leverage ratio, experiences the greatest price reduction. Conversely, the prices of life insurance products covering survival risk increase to varying extents, with prices of deferred annuity insurance products rising more than non-deferred annuities insurance products. The net single premiums for products such as term life insurance, whole life insurance, and endowment insurance, all covering death risk, decrease to varying degrees. The price of term life insurance products decreases by up to 30.43% (for a 30-year-old female), while the price reduction for endowment insurance products is generally within 1%, making the impact on prices of endowment insurance products the lowest among life insurance products covering death risk insurance. The prices of whole life insurance products decrease by around 7%. Annuity insurance products, which covers survival risk, sees prices for various annuity products increase to different extents. The net single premiums for deferred annuity insurance products increases more than those of non-deferred annuity insurance products. The price increase for non-deferred term annuity insurance products is generally within 1%, with the impact of the mortality rate reduction on the price of non-deferred term annuities products being the lowest. The price increase for deferred whole life annuity products is the highest among annuity insurance products. The reduction in mortality rates leads to an approximate 4% increase in the price of a unit amount insured deferred whole life annuity product.

Figure 1 shows the price changes for the two types of life insurance products with the largest decreases and increases (assuming rate of 3% in both Life Table-2023 and Life Table-2013). The price of term life insurance products decreases by up to 34.90%, while the price of deferred whole life annuity products increases by about 5%. The price fluctuations for term life insurance products vary significantly across different ages, whereas the price fluctuations for deferred whole life annuities products are relatively small across different ages. Since deferred annuity insurance is often used for commercial pension purposes, the switch to Life Table-2023 leads to a roughly 5% increase in the price of deferred annuity insurance products per unit amount insured. In practical terms, when the insurance amount is multiplied by thousands or tens of thousands, the premiums for commercial pension insurance will also increase by about 5%. This implies a more pronounced effect on the prices of pension insurance products. The

adjustment of Life Table-2023 indicates that the prices of life insurance products used as pension risk management tools, such as annuity insurance, have risen significantly, leading to a noticeable increase in the cost of pension risk management.

Age, insurance period, and gender differences all have significant impacts on the price fluctuations of life insurance products. The degree of price fluctuation varies greatly under different circumstances. After the switch to Life Table-2023, the price reduction effect of life insurance products covering death risk is more pronounced for younger individuals compared to older individuals, while the price increase effect for life insurance products covering survival risk is weaker for younger individuals compared to older ones. The price reduction effect for life insurance products covering death risk is weaker for products with longer insurance periods compared to those with shorter periods. Conversely, the price increase effect for life insurance products with survival risk is more significant for products with longer insurance periods compared to those with shorter periods. The price reduction effect for life insurance products covering death risk is significantly higher for females compared to males, while the price increase effect for life insurance products covering survival risk is weaker for females compared to males. The price changes for various life insurance products in Table 8 align with the patterns of mortality risk. Differences in age, insurance period, and gender lead to varying degrees of price decreases or increases for life insurance products. Consequently, the price changes for life insurance products differ significantly among different consumers before and after the switch to Life Table-2023.

Table 4 Percentage changes in price of various life insurance products

Product	Business Table		Age	Sex	Insurance Period			
					10 year	20 year	30 year	Whole life
Term life insurance	CL1		30	male	-23.88%	-22.78%	-18.84%	
				female	-30.43%	-30.27%	-26.73%	
			40	male	-22.32%	-17.88%	-15.65%	
				female	-30.28%	-26.06%	-23.00%	
			50	male	-15.62%	-14.56%	-14.70%	
				female	-23.89%	-21.84%	-21.89%	
Whole life insurance	CL1		30	male				-6.12%
				female				-8.64%
			40	male				-5.59%
				female				-8.30%
			50	male				-4.86%
				female				-7.77%
Endowment life insurance	CL2		30	male	-0.03%	-0.20%	-0.66%	
				female	-0.01%	-0.07%	-0.24%	
			40	male	-0.07%	-0.39%	-1.10%	
				female	-0.03%	-0.16%	-0.52%	
			50	male	-0.13%	-0.60%	-1.44%	
				female	-0.06%	-0.33%	-0.96%	
Annuity insurance	Term annuity CL3	Non-delay	30	male	0.03%	0.06%	0.15%	
				female	0.02%	0.06%	0.12%	
			40	male	0.04%	0.19%	0.34%	
		delay		female	0.06%	0.14%	0.28%	
			50	male	0.23%	0.42%	0.71%	
				female	0.11%	0.32%	0.66%	
	Whole life	Non-	30	male	0.94%	1.37%	2.99%	
				female	0.83%	1.35%	2.86%	
			40	male	0.88%	1.31%	2.93%	
		delay		female	0.77%	1.29%	2.80%	
			50	male	0.70%	1.14%	2.75%	
				female	0.62%	1.14%	2.64%	
	Whole life	Non-	30	male				1.09%

annuity CL3	delay	40	female		1.32%
			male		1.61%
			female		1.93%
		50	male		2.39%
			female		2.84%
	delay	30	male		4.22%
		40	female		4.88%
			male		4.16%
			female		4.82%
		50	male		3.98%
			female		4.66%

Note: The result is calculated from life table for actuarial pricing. The method is mentioned in equation (2). The method for calculating the data in other tables is the same as in this table. In the table, deferred annuities for both males and females are calculated with the annuity starting payments at age 60 (the same in table 5, 6). The assumed interest rates for CL1 table and CL3 table in both Life Table-2023 and Life Table-2013 are 3.5%, while the assumed interest rate for CL2 table is 2.5%. (Zhou & Wang 2024)

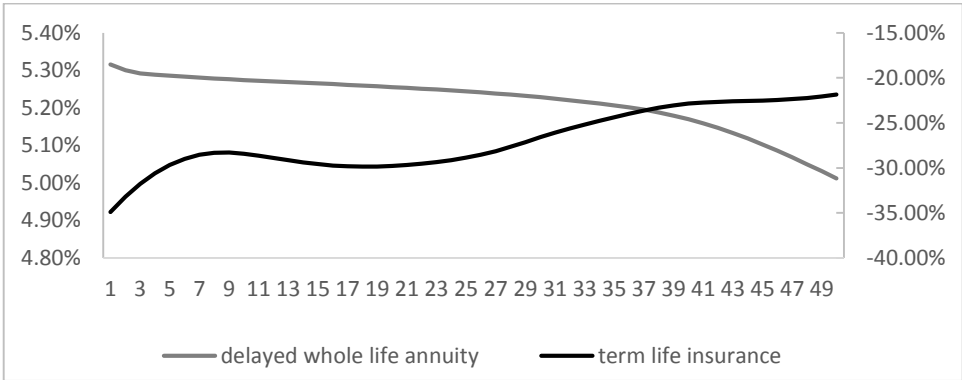


Fig. 1. Price changes of term life insurance products and deferred whole life annuity products for Female (ages 1-50)

Note: The primary y-axis represents the price change of deferred whole life annuity products, while the secondary y-axis represents the price change of term life insurance products. The insurance period for term life insurance products is 30 years. The assumed interest rates for the CL1 table and CL3 table in both Life Table-2023 and Life Table-2013 are 3%, while the assumed interest rate for the CL2 table is 2%. Deferred whole life annuities start payments at age 60.

2. The combined impact of mortality rate reduction and assumed interest rate decrease

(1) The pricing effect of fixed sum assured life insurance products****

Table 5 illustrates the combined effects of reduced mortality rates and lowered assumed interest rates on the pricing of various life insurance products. For term life insurance products, which covers death risk, prices continue to decrease, albeit slightly less than indicated in Table 4. Conversely, prices for whole life products and endowment insurance products, also covering death risk, increase significantly, deviating from the patterns observed in Table 4. Annuity insurance products, which cover survival risk, exhibit a notable price rise compared to Table 4, with deferred annuities products experiencing the most substantial increase. The assumed interest rate reduction affects different life insurance products to varying extents. The price decline for term life insurance products is less pronounced under the combined effect, highlighting its greater sensitivity to mortality rate changes. Whole life, endowment, and annuity insurance products, which have cash values and serve as financial tools for wealth management and retirement planning, are more responsive to changes in assumed interest rate.

**** Unless otherwise specified, the price effects analyzed in this paper pertain to life insurance products with fixed sum insured.

The impact of mortality rate reduction on prices of these products is relatively limited, whereas adjustments in assumed interest rate significantly affect the pricing of cash value life insurance. The combined influence leads to a more pronounced price increase for deferred annuities compared to non-deferred ones. Specifically, the price rise for deferred term annuities is 3 to 9 times that of their non-deferred counterparts, and for deferred whole life annuities, it is 1 to 3 times greater. Deferred annuities products, primarily used for retirement risk management, see a significant price per unit sum insured increase due to the combined effects of decreased mortality rates and lowered assumed interest rates. When the insurance amount scales up, the price increase effect becomes more pronounced. Consequently, the substantial price hike for annuity-based retirement risk management products translates into a significant rise in retirement risk management costs.

Further analyze the pricing trends of cash value life insurance products. As shown in Figure 2, for whole life insurance products, the price increase is more significant for older age groups compared to younger ones. The price increase for deferred whole life annuity products is greater than for endowment insurance products. However, the price increase for deferred whole life annuity products is lower for older age groups compared to younger ones. The price increase for endowment insurance products in non-pension business table 2 is higher than in non-pension business table 1. This may be related to the smaller decrease in mortality rates in non-pension business table 2 compared to non-pension business table 1. When considering the dual impacts of decreased mortality rates and lowered assumed interest rates, the price increase for endowment insurance products calculated using non-pension business table 2 is more influenced by the reduction in assumed interest rate. The price increase for deferred whole life annuity insurance products is the highest among all cash value products. This indicates that products using annuity insurance products as a retirement risk management tool experience the most severe price increases. This could potentially suppress the demand for annuity insurance products as a retirement risk management tool, which is detrimental to the role of annuity insurance products in retirement risk management. After the switch to the Life Table-2023, assumed interest rates for life insurance products are lowered by 0.5% compared to before 2023, and the average mortality rate is reduced by 24.42%. Although the reduction in mortality rates is much greater than the decrease in assumed interest rate, the latter has a more significant impact on the price changes of whole life insurance, endowment insurance, and annuity insurance products. Assumed interest rate has a greater influence on the actuarial pricing of cash value life insurance products than mortality rate. Therefore, the implementation of premium rate policies of life insurance products has a more substantial impact on the price changes of cash value life insurance products compared to the switch in life tables.

Table 5 Percentage changes in price of various life insurance products

Product	Business Table	Age	Sex	Insurance Period			
				10 year	20 year	30 year	Whole life
Term life insurance	CL1	30	male	-21.70%	-18.06%	-10.77%	
			female	-28.47%	-25.98%	-19.31%	
		40	male	-20.03%	-12.78%	-7.35%	
			female	-28.20%	-21.38%	-14.97%	
		50	male	-13.14%	-9.37%	-6.38%	
			female	-21.64%	-16.81%	-13.62%	
Whole life insurance	CL1	30	male				16.13%
			female				16.71%
		40	male				11.92%
			female				11.96%
		50	male				8.34%
			female				7.77%
Endowment	CL2	30	male	4.91%	9.84%	14.44%	

life insurance			40	female	5.00%	10.16%	15.37%	
				male	4.86%	9.49%	13.40%	
			50	female	4.97%	10.01%	14.83%	
				male	4.75%	8.94%	11.82%	
				female	4.92%	9.69%	13.68%	
Annuity insurance	Term annuity CL3	Non-delay	30	male	2.10%	4.22%	6.17%	
				female	2.09%	4.23%	6.16%	
			40	male	2.11%	4.34%	6.32%	
				female	2.13%	4.31%	6.31%	
			50	male	2.30%	4.55%	6.56%	
				female	2.18%	4.48%	6.64%	
		delay	30	male	19.11%	21.92%	25.52%	
				female	19.00%	21.99%	25.68%	
			40	male	13.41%	16.09%	19.51%	
				female	13.31%	16.16%	19.68%	
			50	male	7.86%	10.41%	13.67%	
				female	7.79%	10.50%	13.85%	
	Whole life annuity CL3	Non-delay	30	male				11.15%
				female				12.01%
			40	male				10.49%
				female				11.51%
			50	male				9.95%
				female				11.16%
		delay	30	male				27.65%
				female				29.34%
			40	male				21.55%
				female				23.16%
			50	male				15.60%
				female				17.16%

Note: It is assumed that assumed interest rates for CL1 table and CL3 table in Life Table-2013 are 3%, and assumed interest rate for CL2 table is 2%. For Life Table-2013, assumed interest rates for CL1 table and CL3 table are 3.5%, and assumed interest rate for CL2 table is 2.5%.

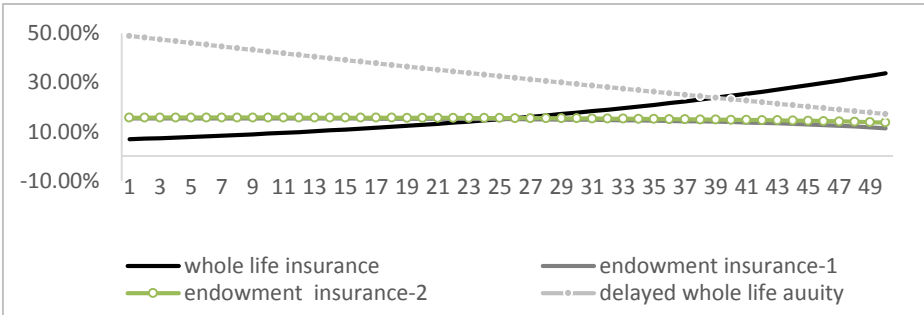


Fig. 2. Price changes of whole life, endowment, and deferred whole life annuity Products for female (Ages 1-50)

Note: Assumed interest rates for CL1 table and CL3 table in both Life Table-2023 and Life Table-2013 are 3%, and assumed interest rate for CL2 table is 2%. For Life Table-2013, assumed interest rates for CL1 table and CL3 table are 3.5%, and assumed interest rate for CL2 table is 2.5%. Endowment life Insurance-1 represents the price change values for CL1 table endowment insurance products with a 30-year insurance period for females, and endowment life Insurance-2 represents the price change values for CL2 endowment insurance products with a 30-year insurance period for females.

(2) The price effect of varying sum assured life insurance products

Benefit amount-adjustable life insurance products are also popular in the life insurance market. The switch to Life Table-2023 will significantly impact the price changes of these products. When considering only the effect of decreased mortality rates, the price of increasing whole life insurance products slightly decreases, with the reduction being more significant for younger individuals under the same conditions. Conversely, the price of increasing annuity insurance products slightly increases, with the increase being more pronounced for older

individuals. Under the combined influence of decreased mortality rates and lowered assumed interest rates, the prices of both increasing whole life insurance and increasing annuity insurance products rise significantly. The price increase for increasing whole life insurance products is the highest, with the price for a 1-year-old female increasing by up to 40.07%, while the price increase for increasing annuity insurance products exceeds 20%, slightly lower than that for increasing whole life insurance. As age increases, the price increase for both increasing whole life insurance and increasing annuity insurance products decreases, highlighting the more significant impact of assumed interest rate on the prices of cash value insurance products.

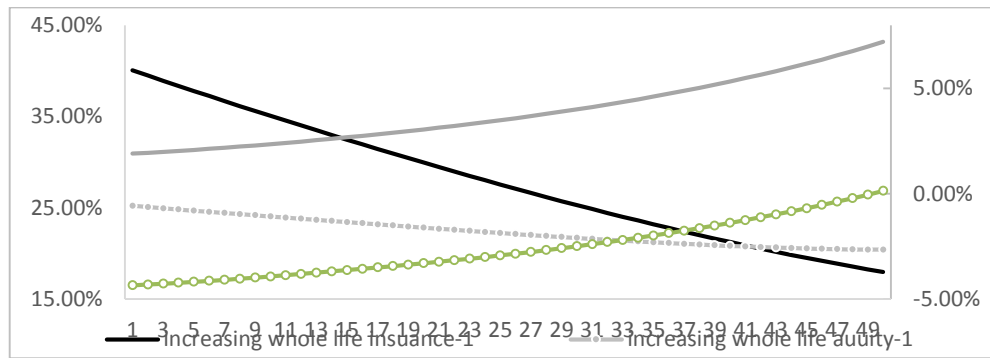


Fig. 3. Price changes of annually increasing whole life insurance and annuity products for Females (Ages 1-50)

Note: Increasing whole life insurance-1 and increasing whole life annuity-1 are plotted on the primary y-axis. When considering only the effect of mortality rate decrease, assumed interest rates for CL1 table and CL3 table in both Life Table-2023 and Life Table-2013 are 3%, while assumed interest rate for CL2 table is 2%. When considering the combined impact of mortality rate reduction and assumed interest rate decrease, assumed interest rates for CL1 table and CL3 table are 3.5%, and assumed interest rate for CL2 table is 2.5% in Life Table-2013. The increasing whole life annuity is a non-deferred annuity insurance with annual payments made at the beginning of each period. Increasing whole life insurance-2 and increasing whole life annuity-2 are plotted on the secondary y-axis.

4. Comparison of life insurance product prices between the GBA and Nationwide

On February 18, 2019, China released the 'Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area,' which mentions insurance in 17 instances, emphasizing the development of the insurance market in GBA as a crucial aspect of regional economic growth. Life Table-2023 was specifically compiled for the insurance market development in the GBA, featuring a life table exclusive to the region. The mortality rates in the GBA are lower than the national average, with male mortality rates lower than the national average but higher than female mortality rates. The gender mortality rate gap is smaller than the national average, and life expectancy in the GBA is higher than the national average. The mortality rates exhibit several differences compared to the national trend, and the GBA faces a more severe aging population issue.

Table 6 shows that compared to the national average, the price leverage effect of insurance products in the GBA is more pronounced. The price decrease for insurance products covering death risk is more significant, while the price increase for insurance products covering survival risk is more pronounced in the GBA. In detail, the prices of insurance products covering death risk in the GBA are all below the national average. Specifically, the price of term life insurance products for males is up to 27.61% lower than the national average for a 30-year-old purchasing a 10-year term policy. The price of whole life insurance products is about 3% lower, and the price of endowment insurance products shows no significant difference, being about 1% lower for a 50-year-old male purchasing a 30-year policy. On the other hand, the price increase for survival risk insurance products in the GBA exceeds the national average. The price of whole life annuity products is up to 3% higher, with a 30-year-old male purchasing a deferred whole life annuity seeing prices 2.27% above the national average.

Figure 4 shows that, compared to the national average, the price reduction for term life insurance products for males in the GBA initially decreases slightly, reaching a maximum reduction of -26.66% at age 17, before starting to increase. As age increases, the price difference between term life insurance products for males in the GBA and the national average decreases. This is primarily due to the greater reduction in male mortality rates in the GBA compared to the national average, resulting in lower male mortality rates in the region. For deferred whole life annuity products for males, the price increase compared to the national average decreases with age. The highest price increase is observed in younger age groups, with the price of a deferred whole life annuity for a 1-year-old male being 2.39% higher than the national average per unit insured amount.

Table 6 and Figure 4 illustrate that, compared to the national average, the influence of age and insurance period on the price fluctuations of various life insurance products in the GBA is consistent with earlier analysis, primarily driven by differences in mortality risk. The price reduction for insurance products covering death risk is more significant for younger groups than for older groups, and it is less for products with longer insurance periods compared to those with shorter periods. Conversely, the price increase for survival risk insurance products is greater for younger groups than for older groups, and it is higher for products with longer insurance periods compared to those with shorter periods.

Table 6 Percentage change in life insurance product prices in the GBA and nationwide (Life Table-2023)

Product	Business Table		Age	Sex	Insurance Period			
					10 year	20 year	30 year	Whole life
Term life insurance	CL4/CL1		30	male	-27.61%	-27.01%	-20.77%	
				female	-22.09%	-18.30%	-16.42%	
			40	male	-26.84%	-19.59%	-12.73%	
				female	-16.27%	-15.44%	-15.17%	
			50	male	-16.13%	-10.40%	-6.35%	
				female	-15.14%	-15.11%	-13.27%	
Whole life insurance	CL4/CL1		30	male				-3.27%
				female				-3.60%
			40	male				-2.79%
				female				-3.43%
			50	male				-2.03%
				female				-3.24%
Endowment life insurance	CL5/CL2		30	male	-0.02%	-0.14%	-0.44%	
				female	0.00%	-0.02%	-0.06%	
			40	male	-0.05%	-0.26%	-0.72%	
				female	-0.01%	-0.03%	-0.13%	
			50	male	-0.07%	-0.37%	-1.03%	
				female	-0.01%	-0.09%	-0.38%	
Annuity insurance	Whole life annuity CL6/CL3	Non-delay	30	male				0.79%
				female				0.63%
			40	male				0.99%
				female				0.87%
			50	male				1.18%
				female				1.23%
		delay	30	male				2.27%
				female				2.02%
			40	male				2.13%
				female				1.98%
			50	male				1.84%
				female				1.92%

Note: In Life Table-2023, the assumed interest rates for CL1, CL2, CL4, and CL5 tables are 3%, while assumed interest rates for CL3 and CL6 tables are 2%.

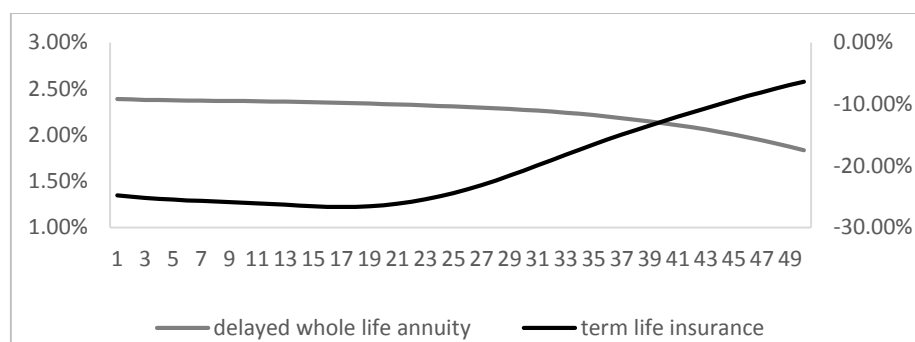


Fig. 4. Price changes of term life insurance and deferred whole life annuity products for male (Ages 1-50)

Note: The primary y-axis shows the price changes of deferred whole life annuity products, while the secondary y-axis shows the price changes of term life insurance products. Assumed interest rates for CL1, CL3, CL4, and CL6 tables in both Life Table-2023 and Life Table-2013 are 3%, and for CL2 and CL5 tables, they are 2%. The insurance period for term life insurance products is 30 years.

V. Main conclusions

5.1 Price effects of the adjustments in Life Table-2023

1. Prices for Life Insurance Products covering death risk decrease, prices for life insurance products covering survival risk increase

After the switch to Life Table-2023, various life insurance products have experienced different levels of price effects. Prices for life insurance products covering death risk have generally decreased to varying extents, while prices for those covering survival risk have increased. Term life insurance, whole life insurance, and endowment insurance products, which ensuring death risk, have all seen price decreases to varying degrees. Term life insurance products have experienced the largest price drop, with prices nationwide decreasing by up to 34.9%. In the GBA, the price drop for term life insurance products is close to 27% compared to the national average. Whole life insurance product prices have decreased by around 6%, while endowment insurance product prices have seen the smallest decrease, with most products experiencing a decrease of less than 1%. Annuity insurance products, which ensuring survival risk, have seen varying degrees of price increases. Whole life annuity product prices have increased more than term annuity product prices, and deferred annuity insurance product prices have increased more than non-deferred annuity product prices. As annuity insurance products are the main financial tools for retirement risk management, the switch to Life Table-2023 has resulted in price increases for various types of annuity insurance products. The price increase for deferred whole life annuity products is the highest, with the price for deferred whole life annuity insurance for females increasing by up to 5.3% per unit insured amount. Deferred annuity insurance products, with its strong retirement risk management function, indicates that the cost of retirement risk management in China has risen due to these price increases.

2. Assumed interest rates have a greater impact on cash value life insurance premiums, significantly increasing retirement risk management costs

Since the switch to a new life table is often accompanied by adjustments in assumed interest rate, incorporating the factor of premium rate adjustments has led to many changes in life insurance product prices that differ from those seen when considering only mortality rate adjustments. For high cash value products such as whole life insurance, endowment insurance, and annuity insurance products, the inclusion of premium rate adjustments has caused price fluctuations that deviate significantly from the patterns observed with only life table

adjustments. Prices for whole life insurance and endowment insurance products have increased, while the increase in annuity insurance product prices is significantly higher than the changes seen when considering only life table adjustments. The price increase for whole life annuity products is higher than that for term annuities products, and the increase for deferred annuity insurance product prices is higher than for non-deferred annuity insurance product. The price increase for deferred whole life annuities product is the largest among all types of life insurance products, with the premium for a 1-year-old deferred whole life annuity increasing by up to 48.97%. The younger the age at purchase, the greater the price increase for deferred whole life annuities product, potentially exerting a greater price impact on the retirement insurance risk for younger groups, which may suppress their demand for retirement risk protection. Since deferred annuity insurance and whole life annuities are primarily products for retirement risk management, the combined effects of assumed interest rate adjustments and life table adjustments have significantly increased the cost of retirement risk management. This could potentially hinder the development of the retirement risk market. Cash value life insurance products serve as both wealth management tools for consumers and instruments for retirement risk management. Therefore, it is crucial for China to carefully determine premium rate policies to provide a more favorable policy environment for retirement risk management.

3. Price effects of life insurance products are more significant in the GBA, with greater retirement risk management pressure on males

The exclusive life table for the GBA shows lower mortality rates than the national average, with a smaller gap between male and female mortality rates. After the switch to Life Table-2023, price changes are more pronounced in the GBA. The price reduction for term life insurance products is significantly higher than the national average. The price of term life insurance products, which are relatively less affected by changes in assumed interest rate, has decreased more in the GBA than nationwide. For a 30-year-old male, the pure risk premium per unit amount insured of term life insurance products decreased by 46.52%, which is 22.45 percentage points higher than the national average, indicating a significant price effect. Under the dual influence of mortality rates and assumed interest rates, the price increase for annuity insurance products in the GBA is higher than the national average. The price mechanism has a more pronounced impact on the rising costs of retirement risk management. The price increase for whole life insurance and endowment products, which have investment and wealth management functions, is lower than the national average, indicating a relatively weaker impact of the price mechanism on investment-related products. In terms of gender differences, the price reduction for male death risk liability products in the GBA is greater than for females. Conversely, the price increase for male retirement risk liability products is higher than for females, suggesting that males in the GBA face more severe pressure in retirement risk management. The increase in retirement risk management costs is more significant in the GBA.

4. Age, insurance period, and gender are important factors influencing prices, with risk differences being the root cause of price changes

The impact of the adjustments in Life Table-2023 on the pricing of various life insurance products is influenced by multiple factors. Age, insurance period, and gender differences are also important factors affecting the price changes of different life insurance products, and these differences are related to risk. Assuming other factors remain constant, after the adjustments in Life Table-2023, the younger the age group, the greater the magnitude of price decreases or increases. Price changes have a more significant impact on the price fluctuations for consumers under the age of 30. The price mechanism has a greater influence on the life insurance consumption of younger groups, potentially incentivizing life insurance consumption among some younger groups through price effects. When consumers have different preferences for risk

protection periods, the adjustments in Life Table-2023 will have different price effects based on the insurance period. For life insurance products covering survival risk, the longer the insurance period, the greater the price fluctuation and the greater the adjustment in insurance costs. For life insurance products covering death risk, the price change magnitude is smaller for longer insurance periods. When the insurance period exceeds 30 years, the price fluctuations caused by the life table adjustments are larger, leading to greater changes in insurance consumption costs. The price reduction for male term life insurance is less than for females, and the price increase for male whole life insurance and endowment insurance is greater than for females (except in the GBA). The price increase for male whole life annuity insurance products is weaker than for females, giving males a price advantage in whole life annuity insurance consumption. The impact of gender differences on price changes is mainly due to differences in gender mortality risk, and price fluctuations are more favorable for developing the female life insurance market.

5.2 Analysis the impact of price mechanisms on the life insurance industry

1. More pronounced price leverage effect

After the adjustments in Life Table-2023, the prices of various types of life insurance products per unit amount insured have shown varying degrees of increase or decrease. Term life insurance product prices have decreased by nearly 50% at most, while the price increase for deferred whole life annuity insurance products has reached up to 30%. The price leverage effect resulting from the reduction in mortality rates and assumed interest rates is quite pronounced. In practical insurance operations, the sum insured is usually set in multiples of thousands or tens of thousands, making the price increases or decreases for various life insurance products more significant. The price leverage effect brought about by the adjustments in Life Table-2023 is notable and will significantly impact the price changes of various life insurance products. Before and after the switch to Life Table-2023, there may be phenomena of increased or decreased sales of certain life insurance products. Every time a new life insurance premium rate policy is implemented in China, the market experiences a ‘hype for product discontinuation’ (for example, during the policy transition in July 2023, when assumed interest rate was lowered from 3.5% to 3%, there was a hype for discontinuation of increasing whole life insurance products^{††††}). The growth in life insurance premium income was significantly higher before the premium policy switch than after, having a notable impact on the market. The significant price differences brought about by the switch to Life Table-2023 may also have a substantial impact on the premium of various life insurance products.

2. Comprehensive price changes influenced by multiple factors

Risk factors such as age, gender, insurance period, premium payment period, and type of insurance significantly impact the prices of life insurance products. The final price changes of various life insurance products are influenced by a combination of factors and may not always result in the maximum discount or the highest price increase. The price fluctuations analyzed in this paper focus on life insurance products covering a single risk or term and do not account for price changes of life insurance products when combining various risks. In practice, life insurance products that cover multiple types of risks offer various protection functions. For example, life insurance may be combined with health insurance (e.g., critical illness insurance embedded in whole life insurance terms) or different life insurance products may be combined. The actual price changes of these combined products depend on the combined effects of various price factors. The price effects of adjustments in Life Table-2023 will be offset by such

^{††††} Expectations of lowered assumed interest rates rise, insurance product ‘Hype for Discontinuation’ Resurges: eastmoney.com.

combinations, making it difficult to determine the peak or trough of price fluctuations calculated in this paper. In practice, the actual price fluctuation effects may not be as significant as the results calculated in this paper. To avoid the impact of price increases brought by the life table switch, insurance companies may combine the liability terms of potentially more expensive products with other types of insurance products when designing insurance products to offset the price increase effects brought by the life table adjustments. Consequently, the price increase effects of comprehensive life insurance products in practice are not as significant as the results calculated in this paper. Conversely, life insurance products that may decrease in price after the life table switch present a favorable advantage for insurance marketing. Insurance companies can leverage this advantage to expand the market and achieve better market promotion effects.

3. Whether pricing mechanisms translate to market shock effects remains unclear

Life insurance consumption is influenced by many factors, and price is just one of them; it is not the decisive factor in life insurance consumption. It remains unclear whether the price leverage effect resulting from the adjustments in Life Table-2023 will have a significant impact on the life insurance market. Therefore, the potential for Life Table-2023 switch to serve as a strategic tool for life insurance marketing is still uncertain. The switch in the life table may cause short-term price fluctuation effects. Some insurance companies might capitalize on this ‘window of opportunity’ to accelerate the growth of premium income for certain life insurance products in the short term. However, the beneficial period of this ‘window’ created by life table switch will not last long, and the long-term development of the life insurance market will still depend on factors beyond price. Once life table switch occurs and some life insurance product prices increase, the previously lower-priced life insurance products will be entirely ‘off the shelves.’ Even if there is a price increase effect, the market will lack low-priced alternatives, making risk loss the key determinant of the market development for these products. After the life table switch, if some life insurance product prices decrease, the rising death risk with increasing consumer age will offset some of the price reduction effects. Thus, the price effect might not necessarily be a long-term advantage for the market development of these life insurance products.

4. Regional differences in life tables will not lead to cross-region consumption mainstream

After the switch to Life Table-2023, the GBA will apply a regional exclusive life table. Compared to other regions, the GBA life table has lower mortality rates and higher life expectancy. This is the first time China has set a life table based on regional differences, leading to significant differences in life insurance product prices across regions. The price reduction effect for life products covering death risk in the GBA is more pronounced, while the price increase effect for life insurance products covering survival risk is more significant. The pricing differences across regions may lead some consumers to choose insurance products from regions with more favorable prices, resulting in cross-regional consumption. However, such cross-regional consumption is unlikely to become mainstream. China's principles of localized consumption limit most cross-regional consumption behaviors. Additionally, insurance consumers typically have limited professional knowledge, making it difficult for them to recognize how regional price differences impact their interests. The development of China's insurance market remains strongly supply-oriented, with regional sales teams exhibiting strong zonal management characteristics, generally not actively guiding the market towards cross-regional consumption. Hong Kong has a more developed insurance market, and there has historically been a significant gap between the life tables of the mainland and Hong Kong's life insurance industries. There was a period when mainland consumers purchased insurance in Hong Kong, leading to a rapid increase in cross-regional consumption. However, this

phenomenon remained limited compared to the mainstream consumption in mainland China, and cross-regional consumption by mainland consumers in Hong Kong did not become mainstream. After the introduction of the exclusive life table for the GBA, there may be a slight increase in cross-regional consumption, but it is unlikely to become the predominant trend.

5. Rising costs of retirement risk management

After the switch to Life Table-2023, the prices of various annuity insurance products have increased to varying degrees, with the price increase for deferred annuity insurance products being the highest. Annuity insurance is a crucial financial tool for retirement risk management, especially deferred annuity insurance products, which have strong retirement risk management characteristics. The switch to Life Table-2023 has resulted in a significant decrease in mortality rates compared to Life Table-2013, implying an increased survival risk and higher retirement risk management costs for society as a whole. Since 2021, due to factors such as the gradual withdrawal of annuity insurance products with an assumed interest rate of 4.025%, increasing whole life insurance product has gradually become a popular insurance product in the market. Although increasing whole life insurance product insure death risk, its relatively flexible 'partial surrender' function allows policyholders to withdraw part of the cash value in advance, partially replacing the retirement risk management function of annuity insurance. However, the primary function of increasing whole life insurance product is still death risk management, and it cannot fully replace the retirement risk management function of annuity insurance products. Even if the market develops various types of insurance products with death risk as the insurance liability, these products still lean towards death risk management from a risk management perspective and cannot serve as substitutes for the retirement risk management function of annuity insurance. After the switch to Life Table-2023, retirement risk management costs have generally increased nationwide, with the highest increase in the GBA. This is particularly unfavorable given China's increasingly severe aging situation.

References

- Bowers, N. L., Gerber, H. Y. and Hickman, J. C. (1997), *Actuarial Mathematics*[M], 2nd Edition, The Society of Actuaries, Ireland.
- Blake, D. and Burrows, W. (2001), Survivor Bonds: Helping to the Mortality Risk[J], *Journal of Risk and Insurance*, 68(2), 339~348.
- Bremberg, S. G. (2017), Mortality rates in OECD countries converged during the period 1990–2010[J], *Journal of Public Health*, 45(4), 436-443.
- Chen, B., and Zhu, W. (2007), Analysis of the Impact of Life Table Revisions on Life Insurance Product Pricing[J], *Peking University CCISSR Forum Proceedings*, 4, 188-200.
- Cowley, A. and Cummins, D. (2005), Securitization of Life Insurance Assets and Liabilities[J], *Journal of Risks and Insurance*, 72(1), 193~226.
- Coviello, E., Seppä, K., Dickman, P. W. and Pokhrel, A. (2015), Estimating Net Survival using a Life-Table Approach[J], *The Stata Journal*, 15(1), 173-185.
- Dickson, C. M. D., Hardy, M. R. and Waters, H. R. (2020). *Actuarial Mathematics for Life Contingent Risks*[M], 3rd Edition, Cambridge University Press, England.
- Gründle, H., Post, T. and Scheluze, R. N. (2006), To Hedge or Not to Hedge: Managing Demographic Risk in Life Insurance Companies[J], *Journal of Risk and Insurance*, 73(1), 19~41.
- Kilgour, J. G. (2016), The New Mortality Tables, Life Expectancy and Pension Plans[J], *Compensation & Benefits Review*, 48(5), 128-140.
- Lledó, J. and Atance, D. (2023), Analyzing the impact of rising mortality in adult ages on financial and actuarial products[J], *Economics Letters*, 233(12), 1-5.
- Li, Z. (2006), The Impact of Life Table Revisions on Life Insurance Companies: An Actuarial Perspective[J], *Southern Finance*, 4, 60-62.
- Lynch, S. M. and Brown, J. S. (2005), A New Approach to Estimating Life Tables with Covariates and Constructing Interval Estimates of Life Table Quantities[J], *Sociological Methodology*, 35(1), 177-225.
- Ma, Y. (2018), The Impact of the Transition between Old and New Life Tables on Basic Life Insurance Product Rates in China[J], *Finance and Economics*, 9, 109-111.
- Muniz, J. O. (2020), Multistate life tables using Stata[J], *The Stata Journal*, 20(3), 721-745.

- Olivieri, A. (2001), Uncertainty in Mortality Projections: An Actuarial Perspective[J], Insurance: Mathematics and Economics, 19(2), 231~245.
- Sun, J. (2023), The Compilation Process of Japan's 2018 Experience Mortality Table for the Life Insurance Industry and Its Implications for China[J], Insurance Theory and Practice, 12, 60-89.
- Wang, X. and Qian, L. (2008), Analysis of the Impact of the Introduction of the 2000-2003 New Life Table on the Life Insurance Industry[J], Applied Probability and Statistics Analysis, 1, 98-106.
- Wang, X., Wang, Y. and Huang, X. (2021), Life Insurance Actuarial Science[M], 3rd Edition, China Renmin University Press, Peking.
- Zhang, Y. (2007), Quantitative Analysis of the Impact of Life Table Updates on Life Insurance Premiums in China[J], Journal of Finance and Economic, 3, 52-57.
- Zhang, Y. (2022), Life Insurance Actuarial Theory and Practice[M], 3rd Edition, Southwestern University of Finance and Economics Press, Cheng Du.
- Zhang, Y. (2004), Application Research of Excel in Life Insurance Actuarial Science[J], Computer Engineering and Applications, 18, 11-12, 46.
- Zhang, Y. (2005), Further Discussion on the Application of Excel in Life Insurance Actuarial Science[J], Computer Engineering and Applications, 35, 17-18, 34.
- Zhou, H. and Wang, X. (2024), The Effect of New Life Table on Life Insurance's Actuary Pricing[J], Review of Economic Research, 3026(10): 105-126.
- Zhou, H. (2023), An International Comparative Study on the Role of Commercial Insurance in the Third Pillar of Pensions[J], Journal of Xi Chang University, Philosophy and Social Sciences Edition, 4, 55-62.