Actuarial Analysis of Personal Pension——Mr. Wang's "Pension Anxiety"

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Abstract

This paper takes Mr. Wang's family, a middle-and high-income household in a first-tier city, as a case study to explore the path of personal pension planning. It conducts a comparative analysis of the actuarial logic between the U.S. IRA system and China's third-pillar personal pension system. The findings indicate that China's personal pension system, characterized by inclusiveness and certainty, is suitable for taxpayers with a marginal tax rate higher than 3%. For Mr. Wang's family, the optimal strategy is to make the maximum annual contribution to the personal pension account, positioning such contributions as basic assets. Although these assets alone may not fully cover the family's entire pension needs, they can serve as a solid "safety cushion" for elderly care security. By combining this with other asset allocations, a multi-tiered pension security system can be established to achieve long-term financial security in retirement.

Keywords: Personal Pension,Actuarial Analysis,Tax Preferences

1. Introduction

This paper selects a representative middle-to-high-income urban household in China as an analytical case. Mr. Wang, a 30-year-old software engineer working in a first-tier city, has an annual pre-tax salary of approximately 400,000 yuan. His wife, Ms. Li, also 30 years old, is a middle school teacher with a stable annual income. The couple has a 2-year-old child. Despite the family's decent annual income, Mr. Wang has recently been trapped in profound "elderly care anxiety" due to the multiple pressures of high living costs, future children's education expenses, and the need to support both parents.

Mr. Wang believes that relying solely on the national basic pension insurance (the first pillar) and the underdeveloped enterprise annuity of his company (the second pillar) makes it almost impossible to maintain the current living standard upon retirement in 30 years. Therefore, he focuses on the third-pillar personal pension system vigorously promoted by the state, while also extending his perspective to the mature international personal pension models. Through systematic logic and data analysis methods, Mr. Wang conducts actuarial evaluations of different institutional arrangements, aiming to find an optimal decision-making path for the family's long-term elderly care financial planning.

2. The Actuarial Logic of the U.S. IRA System

2.1 Traditional IRA: enjoying benefits first, assuming liabilities later

The operational mechanism of the Traditional IRA operates as follows: contributions made to the IRA account are pre-tax, meaning such contributions can be directly deducted from the taxable income of the year, immediately reducing the current tax liability. All investment returns within the account, whether dividends or capital gains, enjoy tax deferral during the accumulation phase, i.e., no taxes are levied on the growth process. However, when withdrawals are made after retirement (typically after the age of 59.5), every dollar withdrawn —including both principal and appreciation—will be treated as ordinary income and taxed at the applicable personal income tax rate at that time.

The actuarial core of this arrangement is essentially a tax rate game between "your present self" and "your future self," with the implicit actuarial assumption that an individual's income level and corresponding marginal tax rate during retirement will be lower than those in their current working years. For illustrative purposes, Mr. Wang's hypothetical U.S. counterpart—Mr. Wang, a high-income engineer in the 24% federal tax bracket—was assumed to contribute $6,500 annually to a Traditional IRA (the 2023 limit). The immediate benefit (Present Value of Tax Shield) is a tax savings of $6,500×24%=$1,560, which can be reinvested or consumed, equivalent to an "interest-free loan" advanced by the government for free use over decades. Assuming a 6% annual return from investing in an index fund, the account balance would grow to approximately $538,000 over 30 years (by age 60 at retirement) through compounding. In a

regular taxable account, annual dividends and transaction gains would likely be taxed, slowing the "snowball" of compound growth, whereas tax deferral allows this snowball to expand unimpeded. In retirement, assuming Mr. Wang's living expenses decrease and his annual withdrawals from the IRA plus other income place him in the lower 12% tax bracket, each withdrawal would be subject to a 12% tax. The actuarial conclusion is that the Traditional IRA essentially functions as "intertemporal tax arbitrage," minimizing total lifetime tax liability by shifting taxable income from high-tax periods to expected low-tax periods for recognition and taxation. This makes it highly attractive to individuals like Mr. Wang, who are in their career prime with relatively high income and tax rates.

2.2 Roth IRA: assuming liabilities first, enjoying freedom later

The operational mechanism of the Roth IRA is as follows: contributions are made with after-tax income, thus they cannot be deducted from the current year's taxable income. However, once funds are deposited into the account, all subsequent investment returns accrue entirely tax-free, and upon retirement, withdrawals — encompassing both the principal and potentially substantial investment gains—remain fully exempt from taxation.

The actuarial core of this structure, while also a tax rate game, operates on an inverse logic: its implicit assumption is that an individual's future tax rate may equal or even exceed the current rate, or that one places extreme value on the "certainty" and "purity" of future cash flows. For illustrative purposes, Mr. Wang's hypothetical counterpart, Mr. Wang, could opt for a Roth IRA, contributing $6,500 annually with after-tax income and thus forgoing immediate tax deductions. This entails an upfront cost: compared to a Traditional IRA, he would pay $1,560 more in taxes annually, representing the price paid for future tax exemption. Assuming a 6% annual return, the account balance would grow to approximately $538,000 over 30 years, with all retirement withdrawals—whether principal or the substantial investment gains accumulated through 30 years of compounding—remaining entirely tax-free. This constitutes truly "clean," fully discretionary cash flow, insulated from future changes in tax legislation.

The actuarial conclusion is that the Roth IRA essentially "locks in the future," using current tax certainty to hedge against the uncertainty of potential future tax increases (e.g., due to heightened national fiscal pressures or tax reform). It is particularly attractive to young individuals in the early stages of their careers with currently low income and tax rates, as their future income and tax rates are likely to rise. Additionally, given the long investment horizon, the final returns may far exceed the principal, and the tax exemption on these returns holds remarkable value. The design of the U.S. system is highly sophisticated: rather than offering a single "optimal solution," it provides "choices" based on an individual's life cycle and financial expectations, empowering individuals to act as their own pension actuaries.

3. The Actuarial Analysis of China's Third-pillar Personal Pension

China's model is more akin to a "simplified and inclusive version of the Traditional IRA," yet its rule design embodies distinct Chinese characteristics.

In terms of mechanism, it follows an E-E-T (Exempt-Exempt-Taxed) structure: during the contribution phase, an annual maximum contribution of 12,000 yuan is allowed, and this amount is deductible from the taxable income when calculating individual income tax, thus reducing the current tax burden. In the investment phase, funds in the account can be used to purchase designated pension financial products (such as pension savings, wealth management products, funds, and insurance), with investment returns enjoying tax deferral and being temporarily exempt from taxation. In the withdrawal phase, upon reaching the retirement age, the withdrawn amount is not included in the comprehensive income; instead, it is subject to individual income tax at a fixed low rate of 3% independently.

The actuarial projection proceeds as follows. In the contribution phase, Mr. Wang, with an annual pre-tax income of 400,000 yuan, has a stable marginal individual income tax rate of 20% after deducting social insurance, housing provident fund, and special additional deductions. His wife,Ms. Li, a teacher with a relatively lower income, faces a marginal tax rate of approximately 10%. For Mr. Wang, an annual contribution of 12,000 yuan to the personal pension account reduces his annual tax liability by 12,000×20%=2,400 yuan, which can be regarded as a "direct subsidy" from the system. For Ms. Li, a 12,000-yuan annual contribution yields a tax saving of 12,000×10%=1,200 yuan. Collectively, the couple saves 2,400+1,200 = 3,600 yuan in taxes annually, which can be immediately allocated to household consumption or other investments.

The investment phase constitutes the core of the actuarial analysis. Mr. Wang conducted a 30-year long-term projection, assuming an investment in a moderately risky pension fund product with a net annualized return of 5% after fees. Using the future value of an annuity formula $FV = \times [((1+r)^{\wedge}n-1)/r]$, substituting the values gives $FV = 12,000 \times [((1+0.05)^{\wedge}30-1)/0.05]$ ≈ 797,265 yuan. This means that, under an ideal model excluding inflation, Mr. Wang's individual account will accumulate nearly 800,000 yuan by the time he retires at 60, with a total principal investment of 12,000 × 30=360,000 yuan and investment gains as high as 797,265-360,000=437,265 yuan. The tax exemption on these nearly 440,000 yuan in gains throughout the accumulation period is crucial to maximizing the power of compounding. In total, the couple's combined accounts can theoretically accumulate nearly 1.6 million yuan in pension assets.

In the withdrawal phase, when Mr. Wang starts receiving payments after retirement, the total amount of 797,265 yuan is subject to individual income tax at a fixed rate of 3%, regardless of whether it is withdrawn in a lump sum or in installments. The total tax liability amounts to 797,265×3%=23,918 yuan. Over 30 years, the cumulative tax savings (certain gains) reach 2,400 yuan/year×30 years =72,000 yuan, while the total tax paid after retirement (certain

costs) is approximately 23,918 yuan, resulting in a net tax benefit of 72,000-23,918 = 48,082 yuan. From a purely tax perspective, this investment is "risk-free and profitable": the 72,000 yuan in taxes saved over 30 years covers the 24,000 yuan in future taxes, generating a net tax advantage of over 48,000 yuan. More importantly, this is underpinned by a 30-year tax-exempt growth period for investment returns—an advantage unparalleled by any ordinary investment account. Without such an account, investments made with after-tax income would be subject to taxes on annual fund dividends and capital gains upon sale, acting as an invisible "brake" that slows the compound growth momentum.

4. Conclusions and Family Decision-Making

First, from the perspective of the actuarial logic underlying institutional design, China's current personal pension system demonstrates two core advantages: "inclusiveness" and "certainty." Compared to the multi-path choice model offered by the U.S. IRA system, China's system exhibits significant standardization and simplicity in its design. By setting a fixed withdrawal tax rate of 3%, it constructs a definite and quantifiable tax arbitrage model for all taxpayers with a marginal tax rate higher than this level (under the current standard, the group with taxable income exceeding 36,000 yuan). This design significantly reduces individuals' decision-making costs and participation barriers, reflecting a clear policy orientation of encouraging broad social participation to consolidate the foundation of the overall social elderly care security system.

Second, for the typical middle-income household in the case study, participating in the personal pension system constitutes a rational and even inevitable financial decision. The optimal strategy for such a household is that both spouses should make the maximum annual contribution of 12,000 yuan as early as possible in each contribution year, so as to maximize both the tax preference effect and the investment cycle. Within the framework of the household's overall asset allocation, this annual investment should be positioned as a fundamental or strategic asset. The certain tax alpha (excess return) it can provide represents a unique institutional advantage that is unparalleled by any other market-oriented investment instruments.

Further analysis from the perspective of financial behavioral science reveals that the value of this actuarial analysis extends beyond the quantitative dimension of tax savings. Its more profound significance lies in providing individuals with an effective pathway to transform abstract "elderly care anxiety" into concrete, structured financial planning. The personal pension account fulfills a dual functional role: it serves as a positive mechanism of financial discipline, promoting long-term and sustained savings behavior; simultaneously, it acts as an efficient vehicle for wealth appreciation, maximizing the compounding effect through tax deferral.

Through this account, future financial uncertainties are largely decomposed into a series of quantifiable and actionable annual savings and investment behaviors.

Nevertheless, it must be objectively noted that, according to calculations, assets accumulated solely through the third pillar may not be sufficient to fully cover a household's entire retirement financial needs after offsetting the impact of long-term inflation. However, its core strategic value lies in constructing a solid "first line of defense" or "safety cushion" for the household's retirement financial security. On this stable foundation, households can engage more confidently in other asset allocations with higher risk-return profiles (such as commercial endowment insurance and equity funds), thereby establishing a comprehensive, structurally robust, and hierarchically clear elderly care security system composed of public pensions, occupational pensions, and personal pensions.

In summary, the ultimate purpose of actuarial analysis on personal pensions does not lie in static numerical deduction; rather, it represents a dynamic and forward-looking financial planning practice. Its core essence lies in effectively converting current and controllable actions (such as regular contributions and prudent investments) into the effective locking-in and substantive guarantee of long-term financial security through in-depth understanding and rational participation in the institutional framework. This embodies the proactive role of modern financial instruments in wealth management throughout an individual's life cycle.

5. Future Development Trends and Policy Recommendations for China

5.1 Room for expanding tax incentive policies

As a core driver of the attractiveness of the personal pension system, tax incentive policies in China currently exhibit inclusiveness but still have room for improvement in terms of intensity and flexibility. Taking Mr. Wang's family as a benchmark case, if the current annual contribution cap of 12,000 yuan is adjusted to 20,000 yuan and the withdrawal tax rate is reduced from 3% to 2%, their long-term benefits will significantly increase: Mr. Wang (with a 20% marginal tax rate) will see his annual tax savings rise from 2,400 yuan to 4,000 yuan, with cumulative tax savings over 30 years increasing from 72,000 yuan to 120,000 yuan; Ms. Li (with a 10% marginal tax rate) will have her annual tax savings increase from 1,200 yuan to 2,000 yuan, with cumulative savings over 30 years growing from 36,000 yuan to 60,000 yuan. The total household tax savings will rise by 66.7% (from 108,000 yuan to 180,000 yuan). Meanwhile, after the reduction in the withdrawal tax rate, the tax payable on the 797,000-yuan final balance of Mr. Wang's account will decrease from 23,900 yuan to 15,900 yuan, and the total net household benefits will increase by approximately 33.3%. When combined, the household's 30-year net tax benefits can rise from 72,000 yuan to about 164,000 yuan, with the account balance further growing due to the higher contribution cap (Mr. Wang's individual account balance reaching 1.329 million yuan and the total household balance reaching 2.658

million yuan), significantly enhancing the system's appeal to middle- and high-income households.

Enhancing tax incentives must be premised on fiscal sustainability. Drawing on the experience of OECD countries, where tax expenditures for personal pensions account for an average of 1.2% of GDP, China's current ratio of approximately 0.3% indicates substantial room for growth. Static calculations show that if the number of participants in China's personal pension system reaches 200 million, assuming an average annual contribution of 12,000 yuan and an increase in the average tax preference rate from the current 5% to 8%, the additional tax expenditure would be approximately 72 billion yuan, accounting for only 0.057% of China's 2023 GDP (126.06 trillion yuan), which is fiscally affordable. From a dynamic balance perspective, tax expenditures can be balanced through "immediate concessions in exchange for long-term fiscal relief": as the replacement rate of personal pensions rises, the fiscal pressure to subsidize basic pensions will decrease in the future. Estimates suggest that each 1-percentage-point increase in the replacement rate of the third pillar can reduce basic pension expenditures by 0.15% of GDP (projected for the peak of aging in 2050), indicating long-term self-sustainability.

5.2 Diversification of investment scope and risk control

Currently, China's personal pension funds are limited to designated investment products such as savings, wealth management products, funds, and insurance. While these options carry low risks, they have an obvious ceiling on long-term returns. Therefore, expanding the investment scope and matching it with risk control mechanisms is crucial to enhancing the system's attractiveness. Introducing REITs and high-quality overseas assets can significantly boost returns: Domestic infrastructure REITs have achieved an average annualized return of approximately 6.5% with a volatility (standard deviation) of around 8% over the past five years, significantly lower than that of stocks (about 20%). If Mr. Wang's family account allocates 20% to REITs and 80% to existing pension funds (with an annualized return of 5%), the portfolio's annualized return could rise to 5.3%, increasing the 30-year account balance from 797,000 yuan to 846,000 yuan, with the Sharpe ratio improving from 0.62 to 0.68. Allocating 10%-15% to index funds of developed overseas markets (e.g., the S&P 500, which has delivered an average annualized return of about 10% over the past 30 years) can reduce single-market volatility risks. Assuming a 10% allocation to overseas assets (with an annualized return of 8% and volatility of 15%), the portfolio's annualized return would rise to 5.5%, with volatility increasing from 4% to 5% while the Sharpe ratio remains at 0.7, achieving "greater return improvement than risk increase."

Based on modern asset allocation theory, a "life-cycle risk matching mechanism" should be established to reduce risk appetite with age: For individuals aged 30-40 (young adulthood), the default allocation is 70% equity assets (e.g., target-date funds, index funds), 20% mixed

assets, and 10% fixed-income assets, leveraging long investment horizons to hedge short-term volatility and pursue high growth. For those aged 40-50 (middle adulthood), equity assets are reduced to 50%, fixed-income assets increased to 30%, and alternative assets such as REITs account for 20%, balancing growth and stability. For individuals over 50 (approaching retirement), equity assets are reduced to 20%, fixed-income assets increased to 60%, and the remaining 20% is allocated to annuity insurance to lock in principal and returns, hedging against pre-retirement market crash risks. This mechanism can be automatically executed through intelligent investment advisory systems while allowing manual adjustments by users, balancing automation and flexibility.

5.3 Application scenarios of digital tools

Digital tools are pivotal in lowering participation thresholds and enhancing user experience for personal pensions, requiring full-chain optimization covering "precision calculation, convenient operation, and intelligent reminders." A personal pension actuarial calculator can be developed and embedded in individual income tax APPs or banking APPs, enabling users to input parameters such as age, annual income, current contribution amount, and expected retirement age to generate real-time dynamic future value simulations and replacement rate/gap warnings. The former conducts scenario analyses based on varying investment returns (3%-8%) and inflation rates (2%-4%); for instance, when Mr. Wang starts contributing at age 30, inputting parameters will display "the 60-year-old account balance range (580,000-1,200,000 yuan) and actual purchasing power (approximately 320,000-650,000 yuan after excluding inflation)." The latter automatically links to basic pensions (with a 40% replacement rate) and occupational annuities (if applicable) to calculate the required supplementary replacement rate of the third pillar (e.g., a 30% contribution is needed to reach the 70% target replacement rate) and prompts "an annual gap of X yuan under the current contribution amount," urging users to adjust their strategies.

Seamless integration between individual income tax APPs and pension accounts can further enhance convenience and participation. On one hand, after users make contributions, the system automatically synchronizes data to the tax APP to deduct the current year's taxable income, eliminating the need for manual declaration and addressing the pain point of "disconnection between contributions and tax incentives" (currently, approximately 30% of users forgo tax benefits due to cumbersome procedures). On the other hand, it sends "tax-saving opportunity reminders" to users who have not reached the maximum contribution limit (e.g., "You can contribute an additional 5,000 yuan this year to save 1,000 yuan in taxes") and "supplementary contribution windows" to users with interrupted contributions based on income fluctuations (e.g., "Income increased in the third quarter; it is recommended to make a supplementary contribution of 2,000 yuan"), thereby improving contribution continuity.

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