Effects of Uncertainty Tolerance on Personal Pension Participation Willingness: Analysis Based on SEM

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Abstract. This study constructed a structural equation model grounded in prospect theory to investigate the multidimensional mechanisms through which uncertainty tolerance (UT) affected personal pension participation willingness (PW). By analyzing 326 valid questionnaires collected through online surveys from China's first batch of pilot regions, it was demonstrated that loss aversion, reference dependence, and probability weighting distortion significantly influenced pension participation decisions through mediators including the UT of policy environment perceptions (PE) and the social environmental and financial situation (EF).The research particularly highlighted the contextual factors in China's transitional pension system reform. Empirical results revealed that PE exerted the strongest direct effect on PW(β=0.484), while the tolerance of financial status uncertainty showed insignificant path coefficients,suggesting institutional trust outweighs economic calculus. This research integrated behavioral economics with pension decision mechanisms,revealing cognitive-emotional interactions in retirement planning, offering theoretical foundations for policy optimization and targeted interventions.

Keywords: Personal pension; uncertainty tolerance; prospect theory; structural equation model.

1 Introduction

The personal pension system, defined as a government-designed "third pillar" of China’ s pension insurance framework, incentivizes voluntary retirement savings through tax benefits and market-oriented operations to supplement existing pension schemes [1]. However, since its implementation, the participation rates, contribution levels and investment amounts have been unsatisfactory, with public participation and willingness to invest remaining low, which is a critical challenge for policy execution and scaling [2].

The observed disparity between high account-opening rates and low contribution engagement ("hot enrollment, cold participation") highlights a theoretical disjunction between traditional economic rationality assumptions and actual decision-making behaviors. Kahneman's Prospect Theory states that individuals' decisions under un-

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certainty are not based on objective utility maximisation, but rather on evaluating the possible outcomes of different choices through a subjective cognitive framework, and ultimately making choices that are not entirely rational. Based on this theory, cognitive biases and loss aversion driven by uncertainty tolerance (UT) may constitute potential behavioural mechanisms that constrain the pension participation [3]. The three core tenets of Prospect Theory—reference dependence (RD), loss aversion (LA), and probability weighting distortion (PD) [4]—explain the current supply-demand mismatches in personal pension products: (1) the annual contribution cap (12,000 yuan) is psychologically anchored to immediate income loss, weakening savings intentions among middle-to-low-income groups; (2) the uncertainties of long-term return amplify LA, compounded by delayed tax incentives, creating behavioral inertia post-enrollment [5]. Besides, UT refers to an individual's acceptance and adaptability in terms of cognitive, emotional or behavioural responses to uncertainty situations, but its cognitive-emotional mechanisms in models of pension behaviour have still not been systematically explored. While existing studies identify the explicit factors like economic capacity and institutional awareness, systematic deconstruction of UT as a decision-making psychological variable remains absent—a new prospective to unlock the "black box" of participation willingness and refining policy precision.

Given the pilot-phase characteristics of the policy, this study focused on Beijing, Shanghai, Chongqing, Fujian, Guangzhou, Shenzhen, and Chengdu—all designated in 2022 as the first batch of pilot regions. These areas combined high population density, educational attainment, and early policy implementation, enabling the data collection via large-scale surveys. Through structural equation modeling (SEM), the effects of uncertainty tolerance on the willingness to participate personal pension was investigated, aiming to advance theoretical frameworks and inform evidence-based policy optimization.

2 Literature Review

Existing studies have examined the factors influencing PW through sociological, economic and psychological lenses. Early economic research emphasized the rational choice theory, interpreting enrollment decisions via cost-benefit analysis frameworks that conceptualize personal pension participation as utility-maximizing intertemporal choices. Empirical evidence confirmed positive correlations between PW and income levels, fixed asset ownership, and financial literacy [6-9]. Emerging studies have further revealed how non-standard employment patterns, self-employed risk exposure, and pension plan transaction costs reshaped intertemporal constraints [10]. While early economic theories provided foundational insights by conceptualizing pension participation through utility-maximizing frameworks, these approaches primarily focused on individual rationality parameters, which might not fully account for collective behavioral dynamics, particularly in contexts where social reference systems influence decision-making. Sociological approaches addressed this gap by incorporating structural variables like social networks and intergenerational cultural norms, positing that the economic decisions were socially embedded. This paradigm highlighted the collective

norms' implicit constraints on pension decisions, transcending the atomized actor models. Research demonstrated significant impacts of familial intergenerational relationships, educational attainment, occupational groups, and employment status on pension enrollment [11]. Besides, psychological perspectives extended the analysis to irrational dimensions, integrating trust, risk perception, temporal discounting biases, and mental accounting into decision-making models [12, 13]. Long et al. [14] identified the direct effects of perceived usefulness, institutional trust, family burdens, and policy support on PW.

In addition, the early enterprise annuity scheme of China's pension reform was stalled due to ambiguous rules, inadequate tax incentives, and implementation delays. Similarly, the 2018 tax-deferred commercial pension pilot saw low enrollment rates owing to complex deduction procedures, limited contribution caps, and return uncertainties – outcomes widely attributed to "wait-and-see" attitudes driven by policy complexity and sustainability concerns. These cases confirm policy uncertainty (frequent rule changes, delayed incentives, commitment credibility) as a critical contextual factor, justifying our framework's focus on Policy Environment perception uncertainty tolerance (PE).

Emerging scholarship has begun re-examining decision paradigms under demographic transitions [15, 16], with particular attention to differential responses to longevity risks and policy uncertainty. Recent conceptualizations positioned uncertainty tolerance as a multidimensional construct, yet its operationalization in pension behavior models remains nascent, particularly regarding its cognitive-affective mechanisms.

This study quantitatively investigated the impacts of UT on PW through two dimensions: cognitive appraisal of environmental dynamics and affective responses to personal instability. Through methodologically integrating questionnaire survey with empirical analysis, the research elucidated a new prospective for the influencing factors of pension participation willingness.

3 Methods

3.1 Theoretical Analysis and Research Hypothesis

This study employed the Prospect Theory as a theoretical framework, integrating the current personal pension industry context of China to develop a conceptual model examining the effects of UT on PW. Theoretical hypotheses were formulated to establish inter-variable relationships, guiding questionnaire design and distribution. In pension financial decision-making, empirical studies by Hofmeyr et al. [17] demonstrated significant deviations between the long-term investment return evaluations and expected utility theory predictions, attributable to irrational decision-making features under Prospect Theory. Accordingly, UT was operationalized into three core dimensions of Prospect Theory—loss aversion (LA), reference dependence (RD), and probability weighting distortion (PD)—with the analysis based on SEM.

(1)Loss Aversion (LA)

Prospect Theory posited that individuals exhibited greater sensitivity to losses than gains. In pension decisions, this asymmetry manifested as exaggerated responses to policy adjustment risks and economic fluctuation losses [18]. Specifically, the low tolerance for policy environment (PE) uncertainty may trigger concerns about potential benefit losses. When the expected returns of policy instruments become ambiguous due to the implementation risks, the participants might perceive policy adjustments as sunk costs, suppressing their engagement of pension products [19]. And financial vulnerability may amplify this tendency, particularly among middle-to-low-income groups who mentally anchored annual contribution caps to immediate disposable income reductions, creating "contribution-as-loss" mental accounting segregation [12].

(2)Reference Dependence (RD)

Decisions were based on dynamic reference points shaped by internal goals (e.g., retirement savings plans) and external environments (e.g., social comparisons). Retirement target clarity (RC) may serve as an internal benchmark, quantified through retirement lifestyle expectations and savings goals. And tolerance for environmental & financial (EF) uncertainty may reconstruct the external reference systems via peer effects and public opinion guidance. High pension participation rates within social networks reduced perceived decision risks by anchoring individuals to group behaviors [20]. Consequently, retirement planning specificity and social embeddedness were prioritized in the questionnaire design, measuring how target references frame decisions and social references guide behavioral choices.

(3)Probability Weighting (PD)

Systematic biases in probability evaluation were observed, characterized by the overestimation of low-probability adverse events (e.g., health crises) and underestimation of moderate-to-high-probability risks [21]. Health status (HS) may influence risk weighting in pension investments through chronic disease risk perceptions and emergency response confidence [22]. Concurrently, policy uncertainty would exacerbate irrational fears of "black swan" events. Thus, the health situation assessments were incorporated to measure PD effects.

Besides, according to Prospect Theory, the economic decisions were anchored to dynamic reference points, with overweighting of low-probability events and underreaction to moderate-high-probability outcomes [23]. Individual UT levels might modulate sensitivity to social reference points, forming the basis for this study's tri-level hypotheses (Fig. 1).

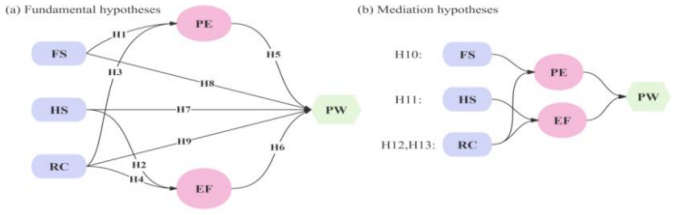

Fig. 1. Effecting factor model of uncertainty tolerance on personal pension participation willingness

3.2 Questionnaire Design

Based on the factors of uncertainty tolerance affecting the willingness to participate in the personal pension system, personal information (Table 1) and UT/PW questionnaires (Table 2) were designed.

Table 1. Questionnaire of personal information

Variable	Item
Basic information	Gender
	Age
	Political complexion
	Educational attainment
	Occupational category
Financial status	Personal annual income in 2024/10^4RMB
	Annual household income in 2024/10^4RMB

The questionnaire assessing UT and PW was structured around three core dimensions of UT: LA, RD, and PD. These dimensions encompassed five measurement domains: PE, FS, RC, EF, and HS. The items were administered using a 5-point Likert scale.

Table 2. Questionnaire of UT/PW

Dimension	Variable	Number	Item
/	PW	PW1	I intend to participate in the personal pension plan.
		PW2	I plan to increase my investment in personal pension plans in the future.
		PW3	I am willing to devote time and effort to understanding personal pension-related information.
LA	PE	PE1	I trust the government's management and supervision of personal pensions.
		PE2	Changes in current pension product investments and tax policies are readily accepted within my cognitive scope.
		PE3	Tax incentive policies enhance my motivation to participate in personal pensions.
	FS	FS1	My career development within the expected working years does not cause confusion or uncertainty.
		FS2	Industry-specific transformation trends and pace are perceived as manageable within my professional context.
		FS3	Unpredictable fluctuations in personal income levels are not associated with significant anxiety.
RD	RC	RC1	Clear objectives are established to acquire retirement-related information.
		RC2	Post-retirement quality of life is systematically considered.
		RC3	Specific savings targets are defined for retirement expenditures.
		RC4	A clear vision of post-retirement living standards is maintained.
	EF	EF1	Anticipated consumption pattern changes over the next three decades do not induce anxiety.
		EF2	Adaptability to inflationary and economic fluctuations over the past decade and projected 30-year horizon is demonstrated.
		EF3	Current social trends—rising unemployment, labor market volatility, declining fertility, and accelerated aging—are not correlated with life or future-related concerns.
		EF4	Value preservation uncertainties in pension products amid rapid societal changes are accepted as tolerable.
PD	HS	HS1	Proactive responses to sudden health emergencies are consistently implemented.
		HS2	Reality acceptance and solution-oriented approaches are adopted when confronting mental health challenges.
		HS3	Unexpected physical or psychological disturbances are not accompanied by debilitating anxiety.

The questionnaire survey on the willingness to participate in personal pensions was conducted in seven pilot provinces/municipalities (Beijing, Shanghai, Chongqing, Fujian, Guangzhou, Shenzhen, and Chengdu) in February 2025. The data collection was implemented via the "*Jianshu*" platform. The respondents were strictly defined according to national eligibility criteria for personal pension participation: urban employees (including workplace-based and flexible employment participants) or urban/rural residents enrolled in basic pension insurance (formerly "New Rural Social Pension Insurance" or "Urban Residents' Social Pension Insurance") who had not yet claimed basic pension benefits. A total of 350 questionnaires were distributed, with time limits (responses under 10 minutes were automatically excluded) and IP address restrictions (one response per ID) to ensure data validity. The invalid responses (illogical answers or statistical outliers) were removed through data cleaning. Finally, 326 valid samples were retained.

4 Results and Discussions

4.1 Descriptive Statistical Analysis

The questionnaire survey on the willingness to participate in personal pensions was conducted in February 2025. The data collection was implemented via the "*Jianshu*" platform. A total of 350 questionnaires were distributed, and 326 valid samples were retained after data cleaning.

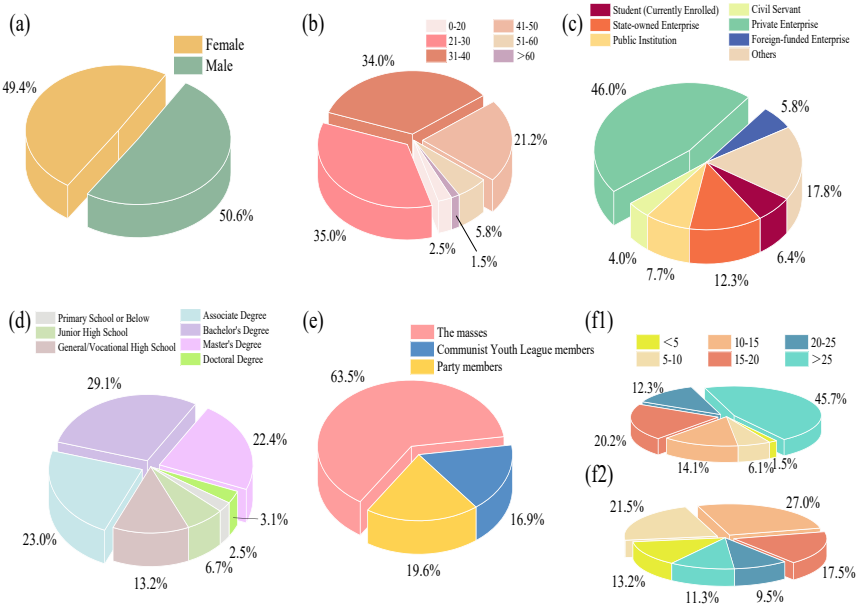

Fig. 2. Results of descriptive statistical analysis: (a) Genders; (b) Ages; (c) Occupational categories; (d) Educational attainments; (e) Political complexions; (f1) Household and (f2) personal annual income in 2024/10^4RMB

Fig. 2 illustrated the demographic characteristics of the sample, from which it can be seen that the gender distribution was balanced (50.6% male, 49.4% female), and most respondents (90.2%) were aged 21 to 50, aligning with China's personal pension eligibility criteria. As for the occupation categories, 51.8% from private/foreign enterprises, 24.0% from state-owned enterprises/public institutions/civil service, 6.4% students, and 17.8% other professions were included, enabling the analysis across employment types. The sample exhibited diversified educational backgrounds: 45.4% held sub-bachelor qualifications (including 13.2% vocational/technical diplomas) while 54.6% possessed bachelor's degrees or higher (29.1% bachelor's, 22.4% master's, and 3.1% doctoral). Political affiliations included: 63.5% non-party members, 16.9% Communist Youth League members, and 19.6% Communist Party members, reflecting extensive coverage and moderate concentration of the samples. And the personal earnings were stratified into six brackets: 34.7% below 100,000 yuan (13.2% <50,000; 21.5% 50,000-100,000), 44.5% between 100,000-200,000 yuan, and 20.8% exceeding 200,000 yuan. Household income exhibited distinct polarization: 45.7% reported over 250,000 yuan, whereas 34.3% fell within 100,000-200,000 yuan. This configuration captured middle-income challenges and high-income heterogeneity, supporting the analysis of economic status–pension decision interactions.

4.2 Model Goodness of fit, Reliability and Validity Assessment

The reliability and validity test was conducted by SPSS 27.0, and the results were shown in Table 3.

Table 3. Results of the reliability and validity assessment

Latent variable	Measured variable	Cronbach's Alpha	Overall Cronbach's Alpha	Standardized loading coefficient	CR	AVE
PW	PW1	0.820	0.905	0.811	0.824	0.609
	PW2			0.768		
	PW3			0.761		
HS	HS1	0.784		0.797	0.788	0.554
	HS2			0.739		
	HS3			0.694		
EF	EF1	0.851		0.747	0.852	0.59
	EF2			0.776		
	EF3			0.773		
	EF4			0.775		
PE	PE1	0.813		0.783	0.817	0.599
	PE2			0.679		
	PE3			0.851		
FS	FS1	0.801		0.836	0.808	0.585
	FS2			0.779		
	FS3			0.671		
RC	RC1	0.815		0.692	0.815	0.525
	RC2			0.749		
	RC3			0.74		
	RC4			0.716		

As shown in Table 3, the Cronbach' s alpha coefficients of all six dimensions exceeded 0.7, with the overall Cronbach' s alpha coefficient of the questionnaire reaching 0.905, indicating an excellent internal consistency in assessing factors influencing residents' participation behavior in personal pensions. Regarding the convergent validity, the standardized factor loadings all exceeded 0.6 with statistical significance, particularly the observed item reflecting perceived value of personal pensions (e.g., PW1 showing a high factor loading of 0.811). This suggests that the measurement indicators effectively capture the core characteristics of the personal pension system. The confirmatory factor analysis (CFA) across six constructs revealed factor loadings above 0.6 with significant p-values. Composite reliability (CR) values surpassed 0.7, while average variance extracted (AVE) exceeded 0.5, confirming convergent validity for all constructs.

The discriminant validity was evaluated by comparing the square roots of AVE with inter-construct correlations. Table 4 indicated that AVE square roots (diagonal values) exceeded corresponding correlation coefficients, validating distinctiveness among dimensions and supporting structural equation modeling feasibility. This demonstrated that the constructed three-dimensional UT model could effectively distinguish the mechanisms through which UT influenced the willingness of personal pension participation, providing methodological assurance for subsequently exploration of multidimensional pathways of how UT affected PW.

Table 4. Results of discriminant validity test

Variables	RC	HS	FS	PE	EF	PW
RC	0.725					
HS	0.402	0.744				
FS	0.370	0.566	0.765			
PE	0.585	0.473	0.533	0.774		
EF	0.291	0.434	0.552	0.483	0.768	
PW	0.606	0.559	0.518	0.765	0.570	0.780

The analysis results of construct validity in Table 5 demonstrated a KMO value of 0.899 (substantially above the threshold of 0.7), indicating strong variable correlations suitable for factor analysis. The Bartlett's test yielded an approximate χ^2 of 3,060.146 with 190 degrees of freedom at a significance level < 0.01, confirming validity of the questionnaire. These metrics verified that the collected data fully met the requirements for factor analysis.

Table 5. Results of KMO measure and Bartlett's sphericity test

KMO measure of sampling adequacy		0.899
Bartlett's test of sphericity	Approximate χ^2	3060.146
	Degrees of freedom	190
	Significance	0.000

As shown in Table 6, the hypothesized model underwent goodness-of-fit evaluation, yielding a CMIN/DF ratio of 1.949. Multiple fit indices including GFI, RMSEA, TLI, and CFI were systematically assessed, collectively demonstrating satisfactory model fit.

Table 6. Goodness-of-fit indices of SEM

Adaptability test index	Adaptation standard	Model result	Adaptability evaluation
CMIN/DF	<3	1.949	Good
RMR	<0.08	0.072	Good
GFI	>0.9	0.913	Good
IFI	>0.9	0.95	Good
TLI	>0.9	0.939	Good
CFI	>0.9	0.949	Good
RMSEA	<0.08	0.054	Good

4.3 Verification of Original Hypotheses

Path Analysis.

The initial model results (Table 7, Fig. 3) showed that non-significant paths for "FS → PW" (β=0.621, $p>0.05$) and the mediation path "RC→EF→PW" (β=0.093, $p>0.05$), leading to the rejection of hypotheses H8 and H13. All other paths achieved significance ($p<0.05$) with positive coefficients, confirming the original hypotheses.

Table 7. Path analysis results of personal pension participation willingness

Hypotheses	Path relationships	Non-standardized path coefficient	Standardized path coefficients	S.E.	C.R.	P	Results
H1	HS → PE	0.352	0.372	0.062	5.666	***	Supported
H2	HS → EF	0.429	0.421	0.077	5.578	***	Supported
H3	RC → PE	0.638	0.458	0.094	6.751	***	Supported
H4	RC → EF	0.23	0.151	0.106	2.166	0.03	Supported
H5	PE → PW	0.436	0.484	0.072	6.089	***	Supported
H6	EF → PW	0.19	0.231	0.048	3.948	***	Supported
H7	HS → PW	0.155	0.185	0.065	2.375	0.018	Supported
H8	FS → PW	-0.032	-0.037	0.064	-0.495	0.621	Rejected
H9	RC → PW	0.254	0.203	0.088	2.896	0.004	Supported

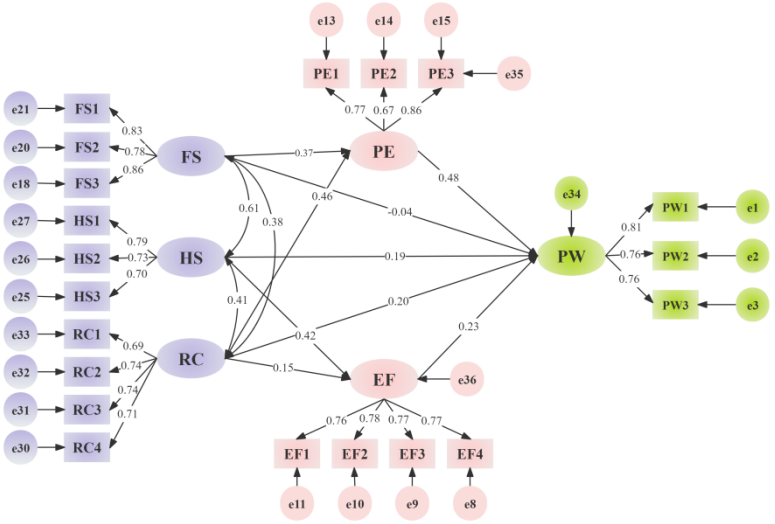

Fig. 3. Analysis results of personal pension participation willingness based on Amos

Analysis of Mediating Effect.

Bootstrap resampling (2,000 iterations) with 95% confidence intervals (CI) was conducted. According to Table 8, the mediation path "RC→EF→PW" exhibited an indirect effect of 0.044 (CI: -0.009, 0.148), containing zero and thus rejecting H13. All other hypotheses were supported as the confidence intervals excluded zero.

Table 8. Results of mediation analysis

Mediation hypotheses	Paths	Estimate	SE	95% CI		P	Results
				Lower	Upper		
H10	HS→PE→PW	0.154	0.052	0.074	0.287	0.001	Supported
H11	HS→EF→PW	0.082	0.035	0.027	0.171	0.005	Supported
H12	RC→PE→PW	0.278	0.08	0.149	0.468	0.001	Supported
H13	RC→EF→PW	0.044	0.037	-0.009	0.148	0.093	Rejected

Analysis of SEM Results.

The hypothesis testing results in Table 9 elucidated multidimensional mechanisms influencing personal pension participation willingness. The positive effects of FS and RC on PE (H1/H3 supported, with RC demonstrating the strongest impact at β=0.458) confirmed the synergistic role of financial fluctuation tolerance and retirement planning specificity in shaping social reference systems. The significant driving effects of HS and RC on EF (H2/H4 supported, HS path coefficient=0.421) highlighted how the chronic disease risk anticipation and policy comprehension jointly shaped the uncer-

tainty tolerance of social environments. Notably, the non-significant negative direct effect of FS on PW (β=-0.037) suggested that the residents may prioritize immediate economic pressures over long-term pension investments under current institutional arrangements. The dominant effect of policy environment perceptions on PW (β=0.484) underscored the critical importance of enhancing policy transparency and implementation stability in alleviating institutional ambiguity anxiety, offering direct empirical evidence for optimizing trust-building mechanisms in personal pension systems.

Table 9. Path coefficients

	FS	RC	HS	PE	EF
PE	0.372	0.458			
EF		0.151	0.421		
PW	-0.037	0.203	0.185	0.484	0.231

5 Summary

5.1 Conclusion and Suggestion

This study uncovered the behavioral mechanisms through which uncertainty tolerance affected personal pension participation willingness via loss aversion, reference dependence, and probability weighting distortion under the prospect theory framework. Empirical results demonstrate that tolerance for policy environment uncertainty had the strongest direct effect on participation willingness (β=0.484), while financial status shows insignificant path coefficients, confirming the "contribution-as-loss" mental accounting segregation among middle-to-low-income groups. The synergy between retirement clarity and social reference frameworks revealed that behavioral interventions could enhance participation by reshaping decision anchors.

Based on this, three policy recommendations were proposed:

(1) Policy calibration of loss aversion dimension

Establish a flexible adjustment mechanism for the contribution amount, allowing the annual contribution base to be dynamically adjusted according to the income fluctuation range (±20%), and eliminating the 'rigid locking of mental accounts' the LA effect value is reduced by 0.12 standard deviation).

(2) Intervention strategy of reference point dependence dimension

The social network demonstration project was constructed. When the community participation rate reached 35%, the peer effect strengthening mechanism (RD effect increased by 19.7%) was started, and the external reference system was reconstructed by embedding the dynamic display of participation rate embedded in social media.

(3) Risk hedging of probability weight distortion dimension

A health-related pension product is designed to convert health management expenditure (≥2000 yuan / year) into pension account equity at a ratio of 1 : 0.5 (HS1 risk perception was reduced by 0.35 standard deviation).

5.2 Limitation and Future work

While this study focused on the first batch of pilot regions in China with high population density and early policy implementation, future research could extend to non-pilot areas and rural participants to enable cross-regional comparisons. The cross-sectional design effectively reveals structural relationships among variables but requires longitudinal data to capture dynamic decision-making evolution. Exogenous factors such as macroeconomic fluctuations and regional policy variations warrant integration to improve generalizability. Subsequent studies may adopt panel data and mixed-methods approaches to investigate generational differences in uncertainty tolerance and decision-anchoring shifts under digital transformation contexts.

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