Title
A Conceptual and Simulation Model of China’s New Rural Social Pension Insurance Program, with Policy Recommendations to Enhance Program Participation and Cost Effectiveness

Author
Ying, Xinda

Publication Date
2022

Peer reviewed|Thesis/dissertation

A Conceptual and Simulation Model of China's New Rural Social Pension Insurance Program, with Policy Recommendations to Enhance Program Participation and Cost Effectiveness

By

XINDA YING
DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Agricultural and Resource Economics

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

Approved:

____
Stephen R. Boucher, Co-Chair

____
Richard J. Sexton, Co-Chair

____
Ashish Shenoy

Committee in Charge

2022

Abstract

The New Rural Social Pension Insurance (NRSPI) is the largest multi-pillar pension program in the world, providing comprehensive support for the rapidly increasing senior population in China. Any rural resident contributing at or beyond the minimum level for at least 15 years is eligible for NRSPI benefits after turning 60 years old. Incorporating both the social pension (basic pension) and the voluntary pension (individual account pension) components gives NRSPI its own unique identity among public pension programs. This dissertation sheds light on the determinants of individuals' participation decisions and the effects of NRSPI on the participants' behaviors such as private savings and personal consumption across life stages. Additionally, this dissertation provides insights into how individuals' NRSPI participation, private savings, and consumption behaviors are likely to vary across both key demographic characteristics and program parameters, thereby providing suggestions for how the government can efficiently achieve policy objectives.

Utilizing a three-period decision model with income uncertainty, I show that life expectancy plays an important role in an individual's decision to participate in NRSPI; not surprisingly, individuals with greater life expectancy are more likely to participate. In the absence of subsidies, no individual would contribute for more than 15 years, which is the minimum requirement to be eligible to receive pension benefits. I show that, although NRSPI contributions crowd out private savings, the program raises total lifetime consumption and, as such, NRSPI has the potential to alleviate rural poverty in China. Comparative static analysis indicates that individuals in different NRSPI participation regimes react to

changes of policy parameters heterogeneously. When uncertainty about life expectancy is introduced into the model, decision-making becomes more complicated, but most qualitative results are consistent with the certainty case.

Based on the conceptual model, I conduct a simulation analysis by randomly drawing 1,000 individuals with characteristics drawn from distributions reflective of the reality in rural China. Simulation results indicate that NRSPI, as designed, is an attractive program because the predicted participation rate under current values of policy parameters is significantly higher than actual participation rates in rural China. These results suggest that the government could increase investment in education and outreach campaigns about NRSPI in order to narrow the gap between predicted and actual participation rates. Results also show that the participation rate is quite sensitive to the size of the monthly basic pension payment and the minimum total contribution, while the average contribution responds strongly to the policy-specified life span after turning 60 years old and the interest rate paid on NRSPI contributions.

The crowding out and poverty-alleviating effects derived in the conceptual framework are confirmed and quantified through the simulation model, and I further demonstrate that these effects mainly result from the basic pension component of NRSPI. From the perspective of the Chinese government, high levels of specified life span and NRSPI interest rate, and low levels of monthly basic pension payment and minimum total contribution are the most efficient way to reduce net government expenditure and maintain a high participation rate.

Results also show that increased central government support to poorer provinces would allow local governments to increase the size of the basic pension payments and reduce the currently large regional heterogeneity in participation rates. A matching subsidy has little effect on participation rates but effectively enhances the average contribution level. Moreover, the government may consider increasing the maximum contribution level since results show a portion of residents would benefit from contributing more than the maximum after turning 45 years old.

This dissertation builds the first comprehensive conceptual framework to analyze the NRSPI and, as such, can be useful in guiding future empirical analysis of the program. By grounding the simulation analysis in data reflective of the rural Chinese context, the results and policy recommendations that emerge from this analysis should be useful to the Chinese government as it seeks to improve the performance of NRSPI in the future.

Acknowledgements

I would like to express my deepest gratitude to my committee co-chairs: Stephen Boucher and Richard Sexton. They met with me for multiple times and spent a lot of time helping me decide the topic of my dissertation in the fall of 2018. During the COVID-19 pandemic, I experienced unprecedented hardships in research as well as personal life. It was their warm encouragements that enabled me to bravely face and overcome all the challenges. Whenever I had questions, they were responsive and helpful. I appreciate their insightful comments on my dissertation, and their time dedicated to me. Since the beginning of 2022, we have been meeting at least once a week. I cannot remember how many times they read my drafts and sent me the detailed feedback. I am truly lucky to have them in my academic journey.

I would like to extend my sincere thanks to Ashish Shenoy, who is my dissertation committee member. He encouraged me to present my work in the departmental seminars, where he and other colleagues provided me with useful suggestions. His feedback on my final draft made the future research directions clear for me.

Thanks should also go to Mark Agerton, Ting Bai, Miki Khanh Doan, Zheng Fu, Dalia Ghanem, Tengda Gong, Meilin Ma, Pierre Mérel, Kevin Novan, Kaiwen Wang, Hanlin Wei, Joakim Weill, Qi Wu, and Xiurou Wu, who offered me advice in many aspects.

I also thank my wife, Peishi Chen, for supporting me all the time. She was always with me even if she could not come to the United States. I owe her much.

Contents

List of Figures ix

List of Tables xii

1 Introduction 1

2 Pension System, Pension Reform, and the NRSPI Program 5

2.1 Background 5

2.2 The Pension System 7

2.3 Pension Reform and the Current Pension System in China 9

2.3.1 The Urban Employees' Social Pension Insurance (UESPI) 9

2.3.2 The Civil Servants and Public Institution Social Pension Insurance (CSPISPI) 10

2.3.3 The Urban and Rural Residents' Social Pension Insurance (URRSPI) 11

2.4 The NRSPI Program 12

3 Literature Review 18

3.1 Pension Reforms 18

3.2 Life Expectancy and Pensions 19

3.3 Voluntary Pensions 20

3.4 Social Pensions 21

3.5 NRSPI: Participation 22

3.5.1 Individual Characteristics 22

3.5.2 Household Characteristics 24
3.5.3 Society Characteristics 24
3.5.4 Policy Characteristics 25
3.5.5 Problems and Policy Recommendations 25
3.6 NRSPI: Effects 26
3.6.1 Effects of Receiving NRSPI Benefits 26
3.6.2 Effects of Participating in NRSPI 28
3.6.3 Effects of NRSPI Implementation 29
3.7 Limitations of the Current Literature 29

4 Conceptual Framework 31

4.1 Model Setup 31
4.2 Simplification 37
4.3 Optimization 42
4.3.1 Individuals with Perfect Foresight 42
4.3.1.1 Period 3 42
4.3.1.2 Period 2: Optimization 43
4.3.1.3 Period 2: Graphical Illustrations for Participation Decisions 55
4.3.1.4 Period 1: Optimization 62
4.3.1.5 Comparative Statics: Parameters of Interest 71
4.3.1.6 Comparative Statics in Period 1: Individual Parameters . . 72
4.3.1.7 Comparative Statics in Period 1: Policy Parameters 78
4.3.1.8 Comparative Statics in Period 1: Discussion 80
4.3.1.9 Comparative Statics in Period 2 82
4.3.2 Individuals without Perfect Foresight 85
4.3.2.1 Period 3 86
4.3.2.2 Period 2 86
4.3.2.3 Period 1 92

4.3.2.4 Discussion 95
4.4 Life Expectancy and Utility in Period 3 96

5 Simulation **99**
5.1 Simulation Parameters 101
5.1.1 Monthly Basic Pension Payment: k 101
5.1.2 Minimum Total Contribution for Eligibility: M 101
5.1.3 Policy-Specified Life Span after 60: T 102
5.1.4 Long-Term Normalized Interest Rates for Savings: r_1 and r_2 102
5.1.5 Life Expectancy at 16: LE 103
5.1.6 Discount Parameter: β 107
5.1.7 Expected Disposable Income and Income Shock in Period 2: μ_2 and σ_2 111
5.1.8 Initial Cash on Hand: I_1 115
5.2 Simulation Model 116
5.3 Simulation Results 117
5.3.1 Participation Rates 118
5.3.2 Simulated and Actual Participation Rates 126
5.3.3 Optimal Values 127
5.3.4 Net Government Expenditures 135
5.3.5 Regional Heterogeneity 145
5.3.6 Government Subsidies 148
5.3.7 Maximum Contribution 151
5.3.8 Impacts of the Utility Dependent on Life Expectancy 152

6 Conclusions **158**
References 163

List of Figures

4.1 Intertemporal Budget Constraint between Period 2 and 3 for Individuals not Participating in NRSPI . . . 46

4.2 Intertemporal Budget Constraint between Period 2 and 3 for Individuals Participating at the Minimum Contribution . . . 49

4.3 Intertemporal Budget Constraint between Period 2 and 3 for Individuals Participating beyond the Minimum Contribution . . . 51

4.4 Substitution and Income Effects When life expectancy Increases for Individuals Participating beyond the Minimum Contribution . . . 52

4.5 Optimal NRSPI Contribution in Period 2 (p_2^*) when $1 + r_2 < b$ . . . 53

4.6 Optimal Savings in Period 2 as Life Expectancy Increases (Interior Solutions) . . . 55

4.7 Optimal Contributions in Period 2 as Life Expectancy Increases (Interior Solutions) . . . 56

4.8 Intertemporal Budget Constraints with Different Participation Decisions for a Given Individual with $1 + r_2 > b$ and $(1 + r_2)M < b(a + M)$ . . . 57

4.9 An Example of Corner Solution Where the Individual Does Not Participate in NRSPI with $1 + r_2 > b$ and $(1 + r_2)M < b(a + M)$ . . . 58

4.10 The Effects of Increasing M on Participation Decisions . . . 59

4.11 The Effects of Decreasing M on Participation Decisions . . . 60

4.12 The Effects of Increasing k on Participation Decisions . . . 61

4.13 The Effects of Decreasing k on Participation Decisions . . . 62

4.14 The Effects of Increasing r_2 on Participation Decisions 63
4.15 The Effects of Decreasing r_2 on Participation Decisions 64
4.16 The Effects of Increasing T on Participation Decisions 65
4.17 The Effects of Decreasing T on Participation Decisions 66
4.18 The Effects of Increasing Life Expectancy on Participation Decisions . 67
4.19 The Effects of Decreasing Life Expectancy on Participation Decisions . 68
4.20 Cases and Corresponding Ranges for Life Expectancy 87

5.1 Life Expectancy at 15 in Rural China in Year 2010 104
5.2 Life Expectancy at 16 in Rural China in Year 2010 104
5.3 Estimated Life Expectancy at 16 in Rural China in Year 2020 105
5.4 Kernel Density for Simulated Life Expectancy at 16 108
5.5 Cumulative Probability of Annual Disposable Income in Rural China in 2020 111
5.6 Kernel Density for Simulated Annual Disposable Income in Period 2 . 113
5.7 Changes in NRSPI Participation Rates as k Increases under Different Values of M ($T = 139$ and $r^{one\ year} = 1.5\%$) 120
5.8 Changes in Proportions of Residents Contributing beyond the Minimum as $r^{one\ year}$ Increases under Different Values of T ($k = 55$ and $M = 1,500$) 124
5.9 Net Government Expenditures under Different Policy Characterizations 137
5.10 Net Government Expenditures When One Parameter Changes 138
5.11 Elasticities of Net Government Expenditure with Respect to One of the Policy Parameters When the Other Parameters Are Fixed 139
5.12 Trade-Offs between Government Expenditures and NRSPI Participation Rates 140
5.13 Unit Net Expenditures under Different Policy Characterizations 141
5.14 Net Government Expenditures under Different Policy Characterizations If Utility in Period 3 Depends on Life Expectancy 155

5.15 Net Government Expenditures When One Parameter Changes If Utility in Period 3 Depends on Life Expectancy 156

5.16 Unit Net Expenditures under Different Policy Characterizations If Utility in Period 3 Depends on Life Expectancy 157

List of Tables

2.1 Taxonomy of Multi-Pillar Pension Systems 8

2.2 Average Basic Pension Benefits across Provinces from 2012 to 2017 . . 13

4.1 Optimal Values in Period 2 (Given s_1 and g_2) 54

4.2 Components of Optimal Values in Period 1 70

4.3 Proportional Changes of Individuals with Different Participation Decisions When the Value of One Policy Parameter Increases 81

4.4 Changes of Optimal Savings and Consumption within the Same Group in Period 1 When the Value of One Parameter Increases 81

4.5 Changes of Optimal Values within the Same Group in Period 2 When the Value of One Parameter Increases 85

5.1 Estimated Parameters and Population Distributional Statistics for the GB2 Distribution of Life Expectancy at 16 107

5.2 Estimated Parameters and Population Distributional Statistics for the GB2 Distribution of Annual Disposable Income 112

5.3 Average Individual Net Income by Age in Rural China in 2015 116

5.4 Means of Simulated Basic Individual Characteristics and Comparisons with the Real Data 117

5.5 Means of Extended Individual Characteristics by Life Expectancy Groups 118

5.6 NRSPI Participation Rates under Different Policy Characterizations ($T = 139$ and $r^{one\ year} = 1.5\%$) 119

5.7 Elasticities of the NRSPI Participation Rate with Respect to k under Different Values of M ($T = 139$ and $r^{one\ year} = 1.5\%$) 121
5.8 Elasticities of the NRSPI Participation Rate with Respect to M under Different Values of k ($T = 139$ and $r^{one\ year} = 1.5\%$) 121
5.9 NRSPI Participation Rates under Different Monthly Basic Pension Benefits k When $M = 30,000$ ($T = 139$ and $r^{one\ year} = 1.5\%$) 122
5.10 NRSPI Participation Rates under Different Policy Characterizations ($k = 55$ and $M = 1,500$) 123
5.11 Proportions of Residents Contributing beyond the Minimum under Different Policy Characterizations ($k = 55$ and $M = 1,500$) 124
5.12 Elasticities of the Proportion of Residents Contributing beyond the Minimum with Respect to T under Different Values of $r^{one\ year}$ ($k = 55$ and $M = 1,500$) 125
5.13 Elasticities of the Proportion of Residents Contributing beyond the Minimum with Respect to $r^{one\ year}$ under Different Values of T ($k = 55$ and $M = 1,500$) 125
5.14 Means of Optimal Values by Groups of Residents ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$) 128
5.15 Means of Optimal Values Excluding Residents with $s_1 = 0$ ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$) 129
5.16 Means of Optimal Values for Residents in Group 1, 2, and 3 When Sample Size is 100,000 ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$) 129
5.17 Means of Optimal Values for Residents Staying in Group 2 and 3 under Different k ($M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$) 130
5.18 Means of Optimal Values for Residents Staying in Group 2 under Different M ($k = 55$, $T = 139$, and $r^{one\ year} = 1.5\%$) 131

5.19 Means of Optimal Values for Residents Staying in Group 2 and 3 under Different T ($k = 55$, $M = 1,500$, and $r^{one\ year} = 1.5\%$) 132
5.20 Means of Optimal Values for Residents Staying in Group 2 and 3 under Different $r^{one\ year}$ ($k = 55$, $M = 1,500$, and $T = 139$) 133
5.21 Average Savings/Consumption Ratio in Period 1 by Groups under Different k and M ($T = 139$ and $r^{one\ year} = 1.5\%$) 134
5.22 Differences and Percentage Changes of Average Optimal Values for NRSPI Participants with and without NRSPI Policy under Different k and M ($T = 139$ and $r^{one\ year} = 1.5\%$) 136
5.23 Comparisons between the NRSPI Participation Rate and Net Government Expenditure in Terms of the Effects of Parameters 137
5.24 Proportions of Basic Pension Payment in Government Expenditure under Different Policy Parameter Characterizations 142
5.25 Average Utilities of the NRSPI and Precise Cash Transfer Programs under Different Policy Parameter Characterizations 143
5.26 Differences of Total Utilities between the NRSPI and Universal Cash Transfer Programs for Residents with Different Participation Decisions under Different Policy Parameter Characterizations 145
5.27 Proportions of Participation and Participation beyond the Minimum across Provinces ($M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$) 147
5.28 NRSPI Participation Rates, Net Government Expenditures, and Unit Net Expenditures When k Increases ($T = 139$, $M = 1,500$ and $r^{one\ year} = 1.5\%$) 149
5.29 NRSPI Participation Rates, Net Government Expenditures, and Unit Net Expenditures When q Increases ($T = 139$, $k = 55$, $M = 1,500$ and $r^{one\ year} = 1.5\%$) 150

5.30 Number of Group 3 Residents Contributing below and above the Maximum Contribution Level in Period 2 under Different Policy Parameter Characterizations . . . 152
5.31 Means of Optimal Values by Groups of Residents ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$) If Utility in Period 3 Depends on Life Expectancy . . . 153
5.32 Differences and Percentage Changes of Average Optimal Values for NRSPI Participants with and without NRSPI Policy under Different k and M ($T = 139$ and $r^{one\ year} = 1.5\%$) If Utility in Period 3 Depends on Life Expectancy . . . 154
5.33 Number of Group 3 Residents Contributing below and above the Maximum Contribution Level in Period 2 under Different Policy Parameter Characterizations If Utility in Period 3 Depends on Life Expectancy . . 156

Chapter 1

Introduction

China is experiencing population aging at an unprecedentedly fast pace because of low fertility and high life expectancy. The problem of old-age support has become more and more severe, especially in rural China. The Chinese government, aiming to provide more comprehensive and generous support to the rural seniors, implemented the New Rural Social Pension Insurance (NRSPI) in 2009.

Designed as a multi-pillar pension scheme, NRSPI has the characteristics of both social pension (basic pension component) and voluntary defined contribution pension (individual account component). It is unique because of three main reasons. First, it is universal and is not contingent on employment, which means most rural residents are eligible. Second, participation is voluntary. Participants can choose their level of individual contribution, but are not allowed to make any further decisions regarding their pension account, including withdrawing and investing. Third, NRSPI benefits are fixed-amount monthly payments that last until death even if an individual's account balance has been exhausted.

It is important to study NRSPI for several reasons. First, the unique characteristics of NRSPI make it meaningful to study since no pension scheme in other countries is identical to it. Second, as NRSPI is the main product of pension reform in China, it may provide useful lessons for other developing countries facing similar demographic problems. Third, policymakers may be able to improve NRSPI based on improved understanding of incentives and barriers to participation. NRSPI has been successful to date in achieving high coverage, but this success, with a high subsidy rate, has put heavy pressure on government finances (e.g., Calvo, Fang, and Williamson, 2016; Choi, 2018). The financial sustainability of NRSPI cannot be taken for granted since the current NRSPI fund will be exhausted in less than 50 years (Mi, Jia, and Zhou, 2016; Wang, Huang, and Sun, 2019; Chen et al., 2021). Fourth, studies show that NRSPI has achieved high participation at least partly through social mobilization in the Chinese context, a process where the government influences and encourages people to participate in certain activities (Lin and Wang, 2012; Zhong and Li, 2012; Yao, 2015). Because of this, the participation behaviors taken by rural residents may not correctly reflect their optimal choices. Investigating the true incentives for NRSPI participation is therefore crucial to determine policy effectiveness.

Considering the reasons stated above, I seek answers to the following research questions. First, what factors affect rural residents' participation decisions, and how do they work? Second, what are the effects of NRSPI participation on individual behaviors, such as savings and consumption? How do these effects differ among participants with different contribution decisions? Third, how do optimal behaviors change with individual or policy characteristics? Fourth, how can the Chinese government efficiently improve the participation rate and average contribution level? Fifth, does NRSPI effectively reduce poverty and regional inequality?

This dissertation contributes to the literature in two aspects. First, I develop a three-period decision model with income uncertainty to study individuals' incentives to participate or not in NRSPI. Prior studies on NRSPI are mostly descriptive or empirical, with little emphasis on conceptual framework. The only prior conceptual model of NRSPI participation is by Jiao and Jing (2014), who set forth a two-period overlapping generations (OLG) model that assumes homogeneous individuals and a fixed amount of NRSPI contribution. Important NRSPI policy parameters are not reflected in this framework. As a result, their model, unlike mine, cannot be used to investigate individual participation, consumption, or savings decisions. My model shows that, without government subsidies that are increasing in years of contribution, participants have no incentive to contribute for more than the minimum requirement of 15 years. Life expectancy plays a key role in decision making, with higher life expectancy leading to higher probability of participation. Individuals with different participation decisions have heterogeneous savings and consumption behaviors. NRSPI contributions crowd out private savings and enhance consumption of the participants before and during the contributing period, and result in higher consumption in old age as well. By raising consumption throughout the life cycle, NRSPI has the potential to reduce poverty in rural China. Policy parameters determine the participation rate, indicating Chinese government is able to encourage participation by adjusting these parameters. The effects of changing individual and policy parameters on contribution, savings and consumption are also elucidated through the model. I analyze the comparative statics using both mathematics and figures, and discuss how individuals with different participation decisions respond heterogeneously to parameter changes. In addition, I explore the case where rural residents are uncertain about their life expectancy, obtaining results that are more complicated but qualitatively consistent with the certainty case.

Second, I conduct a simulation based on the results of the conceptual framework. Simulations are used in several NRSPI studies, but all of them focus on financial sustainability or replacement rate. None of them introduces individual heterogeneity and discusses participation decisions, savings and consumption behaviors, or policy effectiveness (e.g., Wang and Béland, 2014; Tao, 2017; Wang, Huang, and Sun, 2019; Chen et al., 2021). I simulate a "village" of 1,000 individuals with heterogeneous characteristics including life expectancy, annual income, etc. Meanwhile, I characterize NRSPI policy using policy parameters. The distributions of all the parameters are discussed with the help of data from different sources. For instance, I utilize China Family Panel Studies (CFPS) survey data that contain a rich vein of individual and household variables across the country when I am determining the distribution of annual income. With the parameters I analyze participation rates, optimal individual behaviors, net government expenditures, regional heterogeneity, and potential government subsidies.

We need to be aware the simulation model assumes individuals can accurately anticipate their life expectancy. Simulation results indicate that policy parameters affect the NRSPI participation rate heterogeneously, although the participation rate is quite inelastic to these parameters. NRSPI as designed is already highly attractive, and the lower participation rate in reality than projected by the simulation model may be due to the government's inadequate promotion and rural residents' lack of knowledge about NRSPI. Optimal savings and consumption under different parameters are calculated and compared to verify the findings from the conceptual framework. The crowding out and poverty-alleviating effects are also quantitatively evaluated. From the perspective of government, the trade-off between lowering net government expenditure and improving the participation rate can be addressed by choosing parameters that minimize the unit net expenditure. In addition, the simulations suggest that the government may need to financially support basic pension payments in poorer provinces to reduce regional heterogeneity and promote participation. I also demonstrate that a matching subsidy proportional to NRSPI contribution cannot enhance the participation rate. Finally, I show that introducing the maximum contribution leads the residents with adequately high life expectancy to contribute for more than 15 years.

Chapter 2

Pension System, Pension Reform, and the NRSPI Program

2.1 Background

The world has entered an era of "aging society", mainly thanks to two demographic transitions: the decline of fertility and increase of life expectancy. As one of the largest and most rapidly developing economies in the world, China has also seen its population aging greatly, both in absolute and relative terms, in recent decades. Based on the Seventh National Census Data Bulletin, over 260 million people are older than 60 (who are defined as "seniors") in China, accounting for 18.70% of the population (National Bureau of Statistics of China, 2021b). The corresponding proportion in 2010 was only 13.32%. The key role played by the combination of demographic transitions is evident. On the one hand, the fertility rate in China has dropped from 21.06% in 1990 to 8.52% in 2020 (National Bureau of Statistics of China, 2021b). The implementation of China's one-child policy accounted for the fertility decline in the early stage, but it is people's growing conception of not having multiple children that really matters in terms of the subsequent decline. These arguments can be verified by the insignificant effect of the recently highlighted comprehensive two-child policy on boosting the fertility rate (Peng, 2021). On the other hand, life expectancy at birth has surged from 69.15 years to 77.10 years over the same period.

According to the National Bureau of Statistics of China (2021b), 36.11% of China's population was rural in 2020. It is worth noting that the rural population is aging much faster than the urban population and, as a result, the proportion of seniors is rapidly rising. In 2020, just under 24% of China's rural population was 60 or older, implying that rural China is home to approximately 120 million seniors. One of the major causes for the rapidly increasing share of rural seniors is that younger rural residents are more likely to migrate from rural to urban areas, and older rural residents are "left behind" (e.g., Cai et al., 2012; Zhao et al., 2016).[1] What is more, income inequality grows almost at the same pace as population aging in China, as is documented in Wang and Deborah (2009).

Although per-capita income has risen significantly in rural China, it still lags significantly compared to urban areas. Per capita income levels in urban and rural China in 2020 were 43,833.8 and 17,131.5 yuan, respectively.[2] Many rural residents fail to accumulate adequate savings to maintain basic living standards in old age, resulting in the heavy reliance on financial support. While such support mostly came from their children in the past, things have changed greatly in the recent decades. Cai et al. (2012) notice that rural seniors have benefited much less from China's economic growth, compared to other groups such as working-age people and urban seniors. The children of rural seniors are likely to bear higher cost of living as well as higher risk of income because they usually migrate to urban areas and work in informal non-agricultural sectors, which in turn reduce the remittances from children to parents. Given the presence of accelerated population aging and income inequality, rural seniors urgently need extra sources of support other than intra-household transfers. As a response to the increasing need, the Chinese government has been playing a more active role in aiding rural seniors and getting them out of potential poverty, mainly through the social security system.

[1]"Left behind" is frequently used in China, referring to the situation where the parents or children of migrant workers are left alone in rural areas.

[2]The yuan is the base unit of the renminbi, the official currency of China. The exchange rate in July, 2022 was 6.71 yuan/USD.

The social security system in China mainly consists of social pension and social assistance. The objective of social assistance is maintaining the minimum living standards of extremely low-income households. The Dibao program, or Minimum Livelihood Guarantee program, is the most important program in the social assistance system. Designed as an unconditional and means-tested cash transfer program, it is available to all rural households whose income per capita is lower than the Dibao assistance line.[3] The Dibao program is not specially designed for seniors, and its coverage, especially in rural areas, in limited. Compared with social pension, social assistance is not as important in terms of supporting seniors. Consequently, social pension is regarded as the core component of social security system, which I am more interested in since a greater number of rural residents are covered and decision making is also more complicated.

2.2 The Pension System

A pension is a fund that provides transfers to seniors through a collective entity, such as a government (Cai and Cheng, 2014). It is well acknowledged that pension systems are of great importance to maintaining the stability of countries with expanding senior populations. A large literature focusing on pension system has emerged in the last several decades. With an ample number of pension systems across countries, each containing numerous different pension schemes, the definitions and taxonomies of pension systems are not uniform. A widely used taxonomy is proposed by Holzmann and Hinz (2005). According to the taxonomy, a pension system consists of five pillars with different objectives, characteristics, and participation requirements, as presented in Table 2.1. In the table, DB refers to defined benefit schemes, where the benefit formula is defined based on pensioners' years of service and salary history. A DB pension scheme can be either funded or unfunded. The unfunded DB scheme is known as the pay-as-you-go (PAYG) scheme, in which pension benefits are directly paid by

[3]A Dibao assistance line can roughly be considered as the annual income that maintains the minimum living standards for an individual. Rural Dibao assistance lines have a large variance. For instance, at the end of 2013, the average rural Dibao assistance line in Gansu was 748 yuan/year, while the corresponding value in Beijing was 6,235 yuan/year (Ministry of Civil Affairs, 2014).

current pension contributors. DC refers to defined contribution schemes, where employees, employers or both make regular contributions proportional to salary. A DC pension scheme must be fully funded. NDC refers to notional defined contribution schemes, which have the characteristics of both PAYG and DC schemes.

Table 2.1: Taxonomy of Multi-Pillar Pension Systems

Pillar	Objectives	Characteristics	Participation
0	Poverty protection	Basic or social pension, at least social assistance	Universal or means-tested
1	Poverty protection and consumption smoothing	Public pension, publicly managed, DB or NDC	Mandated
2	Consumption smoothing and poverty protection through minimum pension	Occupational or private pension, fully funded DB or DC	Mandated
3	Consumption smoothing	Occupational or private pension, partially or fully funded DB, or funded DC	Voluntary
4	Poverty protection and consumption smoothing	Access to informal supports, other formal social programs, and other individual assets	Voluntary

According to the taxonomy, the zero pillar is non-contributory and in the form of social assistance, basic pension, or social pension, aiming specifically to alleviate poverty in old age. The first pillar mainly consists of public pension, which is provided by the public sector. It requires mandatory contributions that are connected with income, and is usually funded on a PAYG basis. The type of a pension scheme in this pillar can be either DB or NDC. The second pillar, including fully funded DB or DC pension schemes, has independent investment management and also requires mandatory participation. Aimed to protect seniors from relative poverty, the pension benefits from this pillar serve as a supplement to income from the first pillar. The third pillar contains various voluntary pension schemes, which are typically managed by the private sector. The fourth pillar often does not have a legal basis and includes intra-household or inter-generational sources of both financial and non-financial support to seniors.

Holzmann and Hinz (2005) suggest that a pension system should incorporate as many pillars as possible to achieve policy objectives more efficiently. At the same time, a single pension scheme can also contain components from two or more pillars. The multi-pillar design performs better in terms of achieving multiple objectives and reducing various kinds of risks.

In this dissertation, I am primarily interested in pension schemes that are managed by the public sector. Hence, I exclude pension schemes purely run by the private sector in the subsequent discussions on the pension system.

2.3 Pension Reform and the Current Pension System in China

China's pension system is fragmented. Different groups of Chinese people face different pension schemes whose eligibility rules, contribution requirements and benefits differ greatly. Wu (2013) points out that such fragmentation is the main reason for pension inequality in China. However, due to financial and administrative constraints, unequal pension arrangements cannot be entirely eliminated in the near future (Wang and Huang, 2021).

Currently, three major pension schemes exist in China. Each is targeted to different groups. Together, they are intended to cover the entire population.

2.3.1 The Urban Employees' Social Pension Insurance (UESPI)

UESPI was initiated in 1951 but experienced two decades of destruction and restoration because of the Cultural Revolution.[4] Restarted in 1995 and completed in 1997, UESPI was reformed into a multi-pillar pension scheme, in which all employees and employers of private enterprises must participate.

The first component of UESPI belongs to the first pillar, which combines the characteristics of DB and DC schemes. On the DC side, employers are required to contribute 20%

[4]The Cultural Revolution was a sociopolitical movement in China from 1966 until Mao Zedong's death in 1976.

of the total wages paid to the employees. On the DB side, employees who have retired and made contributions for at least 15 years are eligible to receive UESPI benefits. The specific benefit formula for an eligible employee depends on her contributing years and the ratio between her wage and the local average wage.

The second component of UESPI falls in the second pillar, namely a fully funded NDC scheme with individual accounts. Employees are required to contribute 8% of their wages to their individual accounts, but they are not allowed to make any withdrawal or investment decisions with the funds in their account.

The minimum age for retirement eligibility is 55 for female employees and 60 for male employees. Eligible employees receive UESPI benefits every month.

2.3.2 The Civil Servants and Public Institution Social Pension Insurance (CSPISPI)

CSPISPI was established in 1953 for employees working in the public sector. Compared with other pension schemes, CSPISPI is much more generous since it does not require any individual contribution, and the pension benefits can be as high as 80% to 90% of wages before retirement. In addition, the more years working in the public sector, the higher pension benefits will be. The central and local governments are responsible for all the pension payout, which is part of their budgets.

In 2015, CSPISPI was merged into UESPI and therefore adopted the entire set of UESPI policies, such as contribution requirements, eligibility rules, and benefit calculations. It is worth noting that the employees who had retired before 2015 will not be affected, while those who were already in CSPISPI but not yet retired will receive the weighted average of CSPISPI and UESPI benefits.

2.3.3 The Urban and Rural Residents' Social Pension Insurance (URRSPI)

The development of the Chinese pension system in rural areas is far slower than urban areas. It was not until 1991 that the first formal rural pension scheme was implemented in pilot provinces. In the following year, the Old Rural Social Pension Insurance (ORSPI) was established, mainly in coastal provinces that were more developed and in a better position to afford a pension scheme. Local governments were responsible for deciding pension policies and paying all the pension benefits. However, there were several problems that prevented ORSPI from being successful. First, individual rural residents were not responsible for contributing, and the pension funding was far from adequate. The lack of sustainability of ORSPI was evident. Second, there was no clearly specified calculation for pension benefits, and local heterogeneity was significant due to the absence of central government's regulation. Third, the ORSPI fund was managed at village or town level without enough supervision, which inevitably led to high financial risk and inefficiency. As a result, most of rural residents in China had difficulty finding a pension program that was affordable and at the same time provided enough benefits in old age.

At the start of the 21st century, the Chinese government, aware of the potential severe consequences of inadequate coverage and pension benefits in rural areas, sought to develop a new rural social pension system that would cover more rural residents and offer more comprehensive support to rural seniors. The demographic transitions mentioned previously, together with the slow down of economic growth, put heavy pressure on the Chinese government and accelerated the pace of rural pension reform. In 2009, one of the most recent and important programs in the new rural pension system, namely the New Rural Social Pension Insurance (NRSPI), was created to replace ORSPI.

Although the Ministry of Finance firmly objected to NRSPI because of financial concerns, the central government went forward with its establishment (Choi, 2018). The central leadership (thus, the central committee of Chinese Communist Party) played a crucial role in supporting the decision (Stepan and Lu, 2016).

Following the creation of NRSPI in 2009, the Urban Residents' Social Pension Insurance (URSPI) was launched in 2011 to cover unemployed urban residents. Serving as the urban counterpart of NRSPI, URSPI has nearly identical rules with NRSPI, although the values of key policy parameters differ greatly across the two programs. Three years later, NRSPI was combined with URSPI and renamed the Urban and Rural Residents' Social Pension Insurance (URRSPI). This merger is, however, merely notional. Until now, URRSPI still has two different tracks in rural and urban areas, with the urban-rural gap in key policy parameters not significantly closed. Therefore, I still treat NRSPI as an independent pension scheme even after 2014.

As we can learn from the discussion, NRSPI is the only pension scheme that is universally available in rural China and is relatively new compared with other major pension schemes. It naturally follows that I focus on NRSPI given my interest in topics related with old-age support in rural China. I provide a detailed description of NRSPI in the next section.

2.4 The NRSPI Program

Similar to UESPI, NRSPI is a multi-pillar pension scheme. However, the components of NRSPI are different from UESPI. Most importantly, NRSPI is not based on employment and does not require employers to contribute. This characteristic enables NRSPI to have substantially higher coverage than the employment-based social pension schemes, such as the State Pension (Contributory) in the United States, since a large portion of rural residents in China are unemployed, self-employed or employed in the informal agricultural or non-agricultural sectors. According to National Bureau of Statistics of China (2021a), this portion was over 60% in 2020.

In general, there are two major requirements for an individual to be eligible for NRSPI. First, in order to receive NRSPI benefits, the individual must be at least 60 years old. The second is the minimum contribution requirement, i.e., the eligible individual needs to make an annual individual contribution at or beyond the minimum contribution level for at least

15 years.

Table 2.2: Average Basic Pension Benefits across Provinces from 2012 to 2017

Province	2012	2013	2014	2015	2016	2017
Beijing	357.5	390	430	470	560	610
Tianjin	180	200	227.5	245	261	269
Hebei	60	60	65	75	80	90
Shanxi	55	55	67.5	-	-	-
Neimenggu	55	55	67.5	85	90	110
Liaoning	55	55	62.5	85	85	85
Jilin	55	55	55	75	80	-
Heilongjiang	55	55	62.5	70	70	75
Shanghai	370	440	540	645	705	800
Jiangsu	60	80	97.5	105	115	125
Zhejiang	73	80	100	120	120	135
Anhui	55	55	62.5	70	70	70
Fujian	55	55	77.5	85	92.5	100
Jiangxi	55	55	62.5	80	80	80
Shandong	57.5	62.5	70	80	92.5	100
Henan	75	75	75	78	78	80
Hubei	55	55	62.5	70	70	80
Hunan	55	55	67.5	75	80	85
Guangdong	55	65	80	97.5	110	120
Guangxi	55	65	82.5	90	90	90
Hainan	77.5	92.5	127.5	140	-	-
Chongqing	80	80	87.5	-	-	-
Sichuan	55	55	67.5	75	-	-
Guizhou	55	55	62.5	70	70	70
Yunnan	60	60	67.5	-	-	-
Tibet	90	105	130	140	140	150
Shaanxi	55	57.5	67.5	75	75	150
Gansu	55	60	72.5	85	140	155
Qinghai	85	85	110	125	140	155
Ningxia	70	85	115	115	115	120
Xinjiang	55	55	107.5	115	-	-

The NRSPI program has two components. The first component of NRSPI, formally named as the basic pension, is a non-contributory social pension that belongs to the zero pillar in the taxonomy. The central government sets the minimum level of basic pension payment, which is currently 55 yuan per month. Local governments may increase, but not decrease the minimum level. The additional financial responsibility implied by increasing basic pension benefits must be met by the local governments. Conditional on meeting the age and minimum contribution requirements, the size of the basic pension payment does not depend on the amount of the individual's contributions. Hence, all eligible rural residents in the same county receive the same basic pension payment each month. In central and western China, the central government pays 100% of the basic pension benefits. In the wealthier eastern region, the central government pays 50% of the basic pension benefits, while the county-level government (or higher-level government, i.e., prefecture- or province-level) pays the remaining part.[5] Currently, basic pension payout accounts for the largest share of government expenditures on NRSPI. The regional heterogeneity of basic pension is large because economic conditions and budgets of local governments have strong correlations with basic pension benefits. Chi (2022) reports the average basic pension benefits across provinces from 2012 to 2017 in Table 2.2.

The second component of NRSPI is the individual account pension. This is a voluntary and fully funded DC pension which belongs to the third pillar according to the taxonomy. In addition to the fixed basic pension payment, individuals receive a monthly payment based on the balance of their individual pension accounts at the time when benefits begin. This balance consists of all individual contributions, government subsidies, village subsidies and interest earned from the individual account. The interest is calculated using the one-year deposit rate of savings account announced by the People's Bank in China. This rate is usually lower than its counterparts in other financial institutions. The monthly amount of benefits from the individual account equals the total account when the individual turns 60, divided by the policy-specified life span (in months) after 60 years old, which is currently 139 across the country.

NRSPI funds are managed at the county level and include individual contributions, sub-

[5] Province-, prefecture-, county-, and township-level administrative areas correspond to the first-, second-, third-, and fourth-level administrative division units in the current administrative division of China. A village in China serves as a fundamental organizational unit for its rural population and is not considered as an administrative unit. In other words, there is no "village-level government" in China.

sidies from all levels of government and, in some cases, subsidies from villages.

(1). Individual contribution. Each year, NRSPI participants choose their annual contribution level from a menu of discrete values set by the central government. Currently, the minimum and maximum annual contribution levels are 100 and 2,000 yuan, respectively.[6] Since participants needs to contribute for at least 15 years for eligibility, the total minimum contribution required by NRSPI is $15 \times 100 = 1,500$ yuan. Participants are expected to make a single, annual payment, and they may change their contribution level each year. In principle, once an individual decides to participate in NRSPI, they are expected to make an annual contribution each year until they turn 60. In practice, individuals may be allowed to skip a year if they suffer a severe income shock. Make-up contributions can be made only if they are approved by the county-level government. As for the individuals in Dibao households who are extremely poor, the county-level government pays the minimum level of contribution for them each year.

(2). Government subsidies. Benefits from the NRSPI consist of two parts: basic pension benefits and individual account benefits. The central and local governments are totally responsible for subsidizing basic pension benefits, as described above. Furthermore, province-level government may provide matching subsidies. In general, the amount of subsidies is proportional to individual contributions, with the minimum subsidy set at 30 yuan/year for the minimum annual contribution level, i.e., 100 yuan/year. The higher is the level of individual contribution chosen by an individual, the higher is the subsidy she receives. It is worth noting that government subsidies are additional to individual contributions, which means participants still need to contribute the full amount of chosen levels.

(3). Village subsidies. Villages may also provide matching subsidies that function similarly to government subsidies. Nevertheless, villages fund the subsidies by themselves

[6] According to the central government, there are 12 levels of individual contribution available currently: 100 yuan, 200 yuan, 300 yuan, 400 yuan, 500 yuan, 600 yuan, 700 yuan, 800 yuan, 900 yuan, 1,000 yuan, 1,500 yuan, and 2,000 yuan. Province-level government may increase the minimum and maximum annual contribution level according to local economic development level. For instance, the current minimum and maximum contribution levels in Guangxi province are 200 and 5,000 yuan, respectively.

and subsidy rates are decided by the villagers' committee instead of the government.[7]

To better understand the calculation of monthly pension benefits, I provide the following example. Xinda contributes 500 yuan annually for 15 years. In addition, for each of the 15 years, the county-level government provides a 45-yuan subsidy, and Xinda earns 5 yuan in interest each year. Finally, the basic pension in Xinda's county is 55 yuan per month. Once he begins drawing on the pension, Xinda's monthly benefit amount would be $55+(500+45+5)*15/139 = 55+59.35 = 114.35$ yuan, where 55 yuan comes from the basic pension, and 59.35 yuan stems from his individual account. This amount is much larger than the monthly individual contribution, which equals $500/12 = 41.67$ yuan. Thus, the return of NRSPI in this case is high if we do not consider inflation. Additionally, based on this rule, there is no incentive (and it is also not allowed) to make contributions after turning 60 years old since individuals cannot defer receiving benefits. This example highlights the key NRSPI policy parameters that I will include in the conceptual model. They are the basic pension payment, the individual contribution, the NRSPI interest rate, the subsidy, and the specified life span after reaching 60 years (i.e., 139 months). Another key parameter that is not evident in this example is the required minimum contribution which, given the discussion above, is 100 yuan per year.

To regulate NRSPI, the central government enacted the Guidance for Launching the Pilot Program of New Rural Social Pension Insurance (hereafter "the Guidance") in 2009. The guidance stipulates that all rural residents that reach 16 years old (excluding students) may voluntarily participate in NRSPI in the villages where their residence registrations, i.e., *Hukou*, are based (Office of the State Council, 2009). Rural residents apply for NRSPI individually, which means there could be multiple NRSPI participants within a household.

Individuals who meet the age and minimum contribution requirements can receive the fixed amount of monthly pension benefits until death, even if their individual accounts are

[7] A villagers' committee is a mass autonomous organization elected by villagers. People in the villagers' committee are not considered as civil servants, which distinguishes them from government officials

exhausted.[8] If an individual dies before exhausting the individual account balance, the remaining balance, except government subsidies, will be transferred to her legal heirs' individual pension accounts.[9] Given that NRSPI was launched in 2009, individuals who were over 45 years old in 2009 are eligible to receive NRSPI benefits upon turning 60 if they meet the minimum annual contribution level for each year between 2009 and the year they turn 60. They can also choose to make a one-time transfer when they reach 60.[10] Individuals who were at least 60 years old in 2009 were eligible to receive basic pension benefits without making any individual contribution, but at least one of their children ought to participate in NRSPI. Such policy arrangement is known as "bundled participation" and widely considered as the major innovation of NRSPI (Shen et al., 2020).

Unlike individual savings, NRSPI funds can never be withdrawn at any time. Therefore, quitters cannot receive anything and lose their accumulated contributions. The only way to get repaid under NRSPI is receiving NRSPI benefits after meeting both the age and minimum contribution requirements.

Finally, it is also of great importance to distinguish NRSPI participants and recipients. As long as an individual is currently making contributions to NRSPI and not receiving benefits, she is considered as a participant. If an individual is currently receiving NRSPI benefits, she is regarded as a recipient. Based on these definitions, NRSPI participants and recipients are mutually exclusive. This distinction will be applied to the following discussion.

[8] According to previous descriptions, it means these individuals live more than 139 months after turning 60 years old.

[9] This indicates that her legal heirs also need to participate in NRSPI and open their own individual pension accounts, in order to obtain the remaining balance.

[10] This is a temporary policy applicable only to the group of individuals who were between 45-60 years old in 2009. The maximum amount of one-time transfer is 15 $\times$ *local maximum annual contribution level*.

Chapter 3

Literature Review

There are an ample number of studies on pension systems that are relevant to my research. In order to better organize the literature review, I divide the literature into six general topics.

3.1 Pension Reforms

Pension policies are subject to adjustments and modifications, which in turn result in changes in many aspects. Attanasio and Rohwedder (2003) develop a household response model and empirically demonstrate that income-related pension schemes in the United Kingdom, compared with flat-rate ones, have a larger negative effect on private savings. Increasing the normal retirement age of the social pension leads to an increase in the mean retirement age of affected cohort in the United States, shown by Mastrobuoni (2009). This conclusion is confirmed in a simulation conducted by Gustman and Steinmeier (2015). Unsustainable pension policies have severe impacts on the health conditions of affected pensioners, argued by Jensen and Richter (2004) in a study of the Russian pension crisis.

Focusing on the pension reform in China, Hsu, Yoshida, and Chen (2022) develop an OLG model and conduct six potential policy reform exercises. Using a simulation, they demonstrate that extending the mandatory retirement age, combined with reducing the replacement rate, provides the most significant improvement to pension sustainability. On the other side, increasing the contribution rate is the least effective. The preference on extending the mandatory retirement age is also presented in Chen and Groenewold (2017).

Although the pension system in China reduces income inequality among different groups to some degree (Gao, Yang, and Zhai, 2019), the fragmentation in pension benefits is still significant (Chen and Turner, 2015), especially at the supplementary level (Wang and Huang, 2021). The urban-rural gap is expanding under the pension system, as urban residents benefit from the pension system much more than rural residents (Wang, 2006; Zhang, Ding, and Qiu, 2019). In addition, richer regions usually have higher pension benefit levels, as documented in Liu and Sun (2016). Private sector participation, on the contrary, mitigates the inequality between formal and informal sectors (Zheng, Liu, and Jia, 2019).

It is important to enhance people's knowledge about the pension system to ensure a successful pension reform and enhance the participation rate. Niu, Zhou, and Gan (2020) and Bai et al. (2021) find that the more people know about new pension schemes and relevant financial concepts, the more likely they are to participate.

3.2 Life Expectancy and Pensions

Life expectancy is a key factor for policymakers to consider since it is directly related with participation decisions and pension benefits. De Nardi, French, and Jones (2009) show that heterogeneity in life expectancy is largely due to differences in income, sex, and health. Uncertainty about living beyond one's expected lifespan has huge positive effects on saving, which is consistent with Malley et al. (2011). Ridho, Sabli, and Setiawan (2021) find a positive and significant effect of life expectancy on pension fund in Indonesia. Sánchez-Romero and Prskawetz (2017) criticize the pension system with a flat replacement rate, arguing that it always distributes resources from low-ability individuals to high-ability individuals because of the life expectancy gap. Since income is positively correlated with life expectancy and the correlation is larger for males (Walczak, Wantoch-Rekowski, and Marczak, 2021), this life expectancy gap will continue to increase, as presented in Bravo et al. (2021), unless there is a initial pension benefit reduction and/or a gradual diminution in the annual indexation rate of pensions. Another potential solution is proposed by Ayuso, Bravo, and Holzmann

(2017), which is to split the pension scheme into two components, i.e., an individual account pension and a social pension. This multi-pillar design is similar with NRSPI.

3.3 Voluntary Pensions

Most of the voluntary pensions in the literature belong to private pensions in the third pillar. However, it is still useful to explore a series of individual behaviors under various voluntary pension schemes.

Public pension schemes, belonging to the first pillar in the taxonomy, have brought increasing fiscal pressure to many countries since the majority of public pension benefits come from government expenditures. The rapidly expanding aging populations lead the obligations of public pensions to be much higher than the corresponding contributions. Besides proposing stricter requirements for eligibility and reducing public pension benefits, another solution favored by a growing number of countries, according to Casey and Dostal (2013), is to privatize pensions. By encouraging private pension schemes that belong to the second or third pillar in the taxonomy, governments are able to reduce state pension expenditures and assign greater responsibility for financial security in old age to individuals.

Many countries have developed voluntary pension schemes that enable workers to make extra contributions to their individual pension accounts, though policy details vary. Guariglia and Markose (2000), using British data, discover that voluntary contributions are for retirement purposes while conventional savings are mainly driven by precautionary motives. Marcinkiewicz (2016) compares voluntary pension schemes in the third pillar and mandatory pension schemes in the second pillar, arguing that voluntary pension schemes mainly serve as a tool for consumption smoothing, but not for poverty protection. A number of studies, such as Madrian and Shea (2001), Castel (2008), Antolin, Payet, and Yermo (2012), and Rudolph (2016), show that one of the existing problems for voluntary schemes, compared with mandatory ones, is inadequate coverage. Chetty et al. (2014) reveal that, a possible reason accounting for it is that most individuals are passive savers and automatic contributions are more effective at increasing savings than price subsidies, which are commonly used in voluntary pensions. The similar conclusion is also obtained in Van Dalen and Henkens (2018). In addition, an example from India shows that the high minimum contribution level may prevent individuals in the informal sector from participating in the pension scheme (Sane and Thomas, 2015).

Other studies went even deeper and explored the factors that influence individuals' participation decisions on voluntary pension schemes. Voluntary participation is found to be positively correlated with income per capita (Heenkenda, 2016; Marcinkiewicz, 2017), assets (Heenkenda, 2016), knowledge about the pension scheme, financial literacy (Landerretche and Martínez, 2013; Heenkenda, 2016), financial self-control (Castro-González et al., 2020), risk aversion, and financial market uncertainty (Beetsma, Romp, and Vos, 2012), while negatively correlated with family size (Heenkenda, 2016). Education mainly affects the amount of pension contributions rather than participation decisions (Marcinkiewicz, 2017).

Voluntary pensions are likely to increase pension income inequality, which is empirically examined in Babat, Gultekin-Karakas, and Hisarciklilar (2021). Moreover, Romp and Beetsma (2020) show that a large young cohort cannot guarantee the sustainability of a voluntary pension scheme.

3.4 Social Pensions

Different from voluntary pensions, social pensions belong to the zero pillar and typically do not require any individual contribution. Rural residents in China depend heavily on social pension benefits (Zhang, Yang, and Ma, 2009), although these pensions also lead to more severe income inequality (Li et al., 2020). Ebenstein and Leung (2010) find that parents without sons are more likely to participate in social pensions, and also contribute at higher levels. Participants who are making contributions reduce their general consumption, as shown in Bai, Wu, and Jin (2012). Regarding the effects of social pensions, Zhao, Li, and Chen (2016) conclude that individuals participating in any social pension program tend to consume more than those without any pension participation.

The effects of receiving social pension benefits in other countries are also well studied.

Duflo (2003) shows social pension benefits received by women have larger effects on girls in South Africa, indicating heterogeneity by gender. Also using South African data, Ardington, Case, and Hosegood (2009) find an increase of employment among prime-aged people whose family member receives social pension benefits. Juarez (2009) further argues that social pension benefits almost completely crowd out private transfers to seniors in Mexico.

3.5 NRSPI: Participation

Understanding what factors affect NRSPI is of great importance, especially when the government is seeking possible adjustments to the NRSPI policy. There are numerous factors analyzed in the literature, which can be roughly divided into four categories, i.e., individual characteristics, household characteristic, societal characteristics, and policy characteristics.

3.5.1 Individual Characteristics

The individual characteristics examined in the studies can be further categorized into demographic characteristics and cognitive characteristics. I proceed by introducing the former before turning to the latter.

As a characteristic that is directly related with the NRSPI policy, age is examined in many studies. The data and estimation strategies vary greatly, but conclusions are similar. In general, age is estimated to be positively correlated with NRSPI participation (e.g., Hao and Jia, 2011; Wang, 2011; Gao, 2012; Mu and Yan, 2012; Wang, Zhou, and Zhu, 2013; Li and Cui, 2014; Ma, 2016; Zhao et al., 2016; Bian et al., 2018; Xu, 2021). A popular explanation in these studies is that, the older an individual is, the more pressure she has on preparing for old-age support and the more willing she is to participate in NRSPI. Based on my conceptual model, rural residents younger than 45 do not have the incentive to participate, which is consistent with these studies. Nevertheless, Zhang (2010) finds a negative effect of age on NRSPI participation.

As for individual income, Zhang (2010), Hao and Jia (2011), Gao (2012), Chang et al. (2014), Liu and Xu (2014), Ma (2016), and Xu (2021) all show a significant positive effect of income on NRSPI participation. Lin and Wang (2012) and Mu and Yan (2012), on the contrary, obtain a negative relationship between income and participation. What is more, Gao (2012) and Li and Cui (2014) argue that there is no significant effect due to income. It is also the conclusion of my conceptual work which shows that income mainly affects average contribution level rather than participation.

The impact of education on participation is more controversial, mainly because education is highly correlated with individual income and often dropped from estimating equations. While Zhang (2010) and Zhao (2020) find a positive correlation between education and participation, most of the studies, such as Gao (2012), Lin and Wang (2012), Mu and Yan (2012), and Liu and Xu (2014), contend that education negatively affects participation.

The gender difference in participation is also worth noticing. Male individuals are less likely to participate in NRSPI due to lower life expectancy, as stated in Wang (2011) and Xu (2021). Lin and Wang (2012), however, obtain the opposite conclusion.

Health condition is also considered as an important determinant of NRSPI participation. In most cases, health condition is a categorical variable that is self-reported by the rural residents. The higher value it has, the healthier a rural resident is. Almost all the studies, including Hao and Jia (2011), Gao (2012), Mu and Yan (2012), Liu and Xu (2014), and Xu (2021), identify a negative impact of health on participation, probably because healthier individuals are less worried about life at old age. Only Ma (2016) argues that individuals with the worst health condition are less likely to participate because of low life expectancy.

Besides, Chang et al. (2014) point out rural residents working outside of their villages are less likely to participate in NRSPI. Wang (2011) and Gao (2012) show participation is positively correlated with working in the agricultural sector. The positive effect of martial status is documented in Lin and Wang (2012).

Some studies also emphasize the importance of cognitive characteristics, arguing they are even more decisive in terms of NRSPI participation than demographic characteristics (e.g., Li and Cui, 2014). In these studies, successfully measuring cognitive characteristics becomes crucial. The first cognitive characteristic that is widely analyzed is knowledge about

NRSPI. Hao and Jia (2011), Mu and Yan (2012), Jin and Liu (2013), Wang, Zhou, and Zhu (2013), Chang et al. (2014), Li and Cui (2014), and Liu and Xu (2014) all confirm that more knowledge about NRSPI increases the probability of participation.

Two types of trust are often studied: trust in other people (sometimes named as social trust) and trust in the government. Ma (2016) and Ding et al. (2019) describe how trust in other people promotes the participation rate. Meanwhile, Mu and Yan (2012), Ma (2016), and Wu, Zhang, and Lin (2021) find a positive participation effect of trust in the government.

The preferred old-age support mode also matters. Lin and Wang (2012), Li and Cui (2014), Liu and Xu (2014), and Bian et al. (2018) find that, individuals who are more in favor of other old-age support modes except pensions or receive more transfers from children are less likely to participate in NRSPI.

3.5.2 Household Characteristics

At the household level, family size, number of children and number of sons are correlated with each other. Zhang (2010) and Gao (2012) show family size negatively affects NRSPI participation. Similar negative effects are found for number of children in Hao and Jia (2011) and Wang (2011), and for number of sons in Liu and Xu (2014).

Furthermore, Zhao et al. (2016) and Xu (2021) argue that household assets have a positive effect on participation. Hao and Jia (2011) and Lin and Wang (2012) claim that households with more arable land per capita have higher incentives to participate in NRSPI, but Zhang (2010) obtains an opposite result. Lin and Wang (2012) also point out that household income per capita, different from individual income, negatively affects participation.

3.5.3 Society Characteristics

In terms of society characteristics, Zhao and Qu (2021) find the choices and characteristics of peers significantly affect an individual's participation and contribution decisions, but have no effect on participation will. Tao et al. (2021) claim that stronger kinship networks discourage rural residents from participating in NRSPI.

It is well-acknowledged that regional differences are considerably large in NRSPI participation. Many studies using logit, probit, or fixed effects models, such as Lin and Wang (2012), Chang et al. (2014), and Zhao et al. (2016), identify significant regional effects at village, county, and/or province level.

3.5.4 Policy Characteristics

The government can influence participation by multiple ways, as stated in Zhao et al. (2016). Jin and Liu (2013) and Lin and Zhang (2019) show that providing incentive subsidies significantly increases NRSPI participation, while providing matching subsidies does not. The positive effect of social mobilization is documented in Zhong and Li (2012) and Yao (2015). However, these studies also indicate that subsidies and social mobilization only enhance the scope of participation (i.e., whether participate or not), but not the depth of participation (i.e., the level of contribution).

3.5.5 Problems and Policy Recommendations

Under current NRSPI policy, the minimum level of contribution is preferred by most of NRSPI participants. Lu (2012), Lei, Zhang, and Zhao (2013), and Nie and Zhong (2014) blame it to the low replacement rate, inelasticity of subsidies, and inadequate information.

Wang and Béland (2014) calculate the annual growth rate of the NRSPI funding gap, which is as high as 10.34%. Mi, Jia, and Zhou (2016) simulate the operation of the NRSPI fund, finding that the NRSPI fund will be exhausted in 2051. Wang, Huang, and Sun (2019) further argue that the NRSPI fund will run deficits in 2042 under a one-child policy and in 2075 under two-child policy. All the results indicate that current NRSPI policy is not financially sustainable.

Considering feasibility and financial sustainability, Calvo, Fang, and Williamson (2016) suggest switching NRSPI to a more generous social pension pillar and a matching DC pillar, in order to encourage participation and contribution. Similar suggestions can be found in Zhao et al. (2016) and Chen et al. (2021). Mi, Jia, and Zhou (2016), on the other side, state it suffices to change the policy parameters, which include policy-specified life span, monthly basic pension payment, and individual account interest rate.

3.6 NRSPI: Effects

Studies on the effects of NRSPI have three major categories. The first category focuses on the effects of receiving NRSPI benefits on the recipients. The second category analyzes the effects of contributing to NRSPI on the participants. The third category looks at the effects of NRSPI implementation of different groups of rural residents. Within each category, the effects on numerous aspects, such as individual behaviors or welfare, are explored.

3.6.1 Effects of Receiving NRSPI Benefits

The first category enjoys dominant popularity in the current literature of NRSPI and therefore contains a great number of studies. NRSPI benefits add to the income in old age, and studies in this category as a result focus on the income effects of NRSPI. For a clearer presentation, I separate these studies based on their main topics.

Consumption is one of the most important individual behaviors to analyze since it has a strong connection with NRSPI benefits. Some studies focus on the total consumption (or general consumption). In general, total consumption is increasing for NRSPI recipients and their households, although quantitative results differ greatly due to choices of data and estimation methods (Zhang, Giles, and Zhao, 2014; He and Jiang, 2015; Wang, 2017; Zhang, Luo, and Robinson, 2019; He and Li, 2020; Jiang, 2020). Shi (2022), by contrast, find no significant effect on total consumption. When it comes to consumption structure, most studies show the most significant positive effects of NRSPI receipts on food consumption (Zhang, Luo, and Robinson, 2019; Zhang and Wang, 2019), daily necessity consumption (Jiang, 2020) , utility consumption (Chen, 2017), or the combination of these three (Huang and Hu, 2018; He and Li, 2020). In addition, (Tang, Sun, and Yang, 2021) claim that NRSPI benefits substantially enhance education consumption on children.

Another behavior of great interest is the labor supply of NRSPI recipients and their family members. For the recipients, most of studies confirm that NRSPI benefits reduce their working hours, especially in the agricultural sector, and increase the possibility of retirement (Zhang, Giles, and Zhao, 2014; Chen, Bengtsson, and Helgertz, 2015; Shu, 2015; Guo, 2016; Li, Wang, and Zhao, 2018; Lin et al., 2018). There are also some studies finding no significant effect on labor supply (Hua, Zhang, and Liu, 2022; Shi, 2022). Moreover, Ma (2020) finds that NRSPI benefits do not affect the labor supply of recipients' prime-aged adult children.

NRSPI also influences the old-age support mode by increasing the income for seniors, as I have described. Findings in the literature are diverse, highlighting the heterogeneous effects on the households in different income quantiles and reflecting the power of bundled participation. Some studies emphasize the crowding out effect of NRSPI benefits on intra-household transfers, stating that seniors will be less dependent on the financial support from their children (Zhang, Li, and Hu, 2017; Li, Wang, and Zhao, 2018; Zhang, Luo, and Robinson, 2019; Liu, 2020). Such effect is more likely to occur in richer households where parents make NRSPI contributions by themselves (You and Niño-Zarazúa, 2019). For those with low income, receiving NRSPI benefits even increases net transfers from children (Jin, Wang, and He, 2018; Ning et al., 2019; You and Niño-Zarazúa, 2019). Other studies cannot find any significant effect brought by NRSPI benefits in terms of support from children (Ning et al., 2019; Hao, Zhao, and Zhang, 2021).

NRSPI benefits significantly improve both physical and mental health conditions for the recipients, although mental health is evidently of greater interest to most studies (Zhang, Giles, and Zhao, 2014; Ding, 2017; Cheng et al., 2018; Zhang, Luo, and Robinson, 2019; Pan et al., 2021; Wang and Zheng, 2021; Xia and Jin, 2021). In addition, the spillover effect of NRSPI benefits allows the children under 15 to increase nutrition intake and health care consumption, which improves their physical and mental health (Zheng, Fang, and Brown, 2020; Xu and Zhang, 2022). The effect is more significant for boys, left behind, and in poor health condition.

In terms of household assets, Liu (2019) shows that NRSPI benefits significantly reduce the proportion of financial assets held by recipients' households, but Xu et al. (2022) obtain the opposite conclusion.

Using simulations or estimations, studies point out that the current replacement rate for NRSPI is too low, especially in poor regions. Low benefit levels fail to meet the basic needs of recipients (Tao, 2017; Chen et al., 2021).

NRSPI benefits also improve the quality of life in many aspects (Liu et al., 2015; Jin, Wang, and He, 2018). The recipients reallocate their time and spend more on taking care of grandchildren (Li, Wang, and Zhao, 2018). This effect is more significant for recipients in rich households (You and Niño-Zarazúa, 2019). Grandchildren's school enrollment and literacy skills are also enhanced (Zheng et al., 2022). What is more, NRSPI recipients are less likely to live with their adult children, especially sons (Chen, 2017; Zhang, Luo, and Robinson, 2019).

The poverty-alleviating effect of NRSPI benefits is presented in Zhang, Giles, and Zhao (2014)and Zheng and Wang (2020), mainly thanks to more disposable income from NRSPI as well as adult children. However, Wang, He, and Bi (2022) document an increase in poverty vulnerability with NRSPI benefits. Additionally, Chi (2022) finds that NRSPI benefits, in general, narrow the income gap and reduce income inequality.

3.6.2 Effects of Participating in NRSPI

Compared with the recipients, NRSPI is likely to have different effects on the participants, since they are making contributions to NRSPI and yet receiving nothing. While they are expecting a stable income source in the future, their current disposable income is reduced. The number of studies in this category is much lower than the first one. Estimation strategies in this category of studies are very similar to the first one, although RD approach is no longer used since there is no age threshold for the participants.

The effect of NRSPI participation on consumption is generally positive but less significant than the effect of NRSPI benefits (He and Jiang, 2015; He and Li, 2020; Tang, Sun, and Yang, 2021). In some studies, the effect is insignificant, and the marginal propensity of consumption is lower for younger participants (Su, 2017; Wang, 2017).

Jiao and Jin (2014) show conceptually that NRSPI contribution will crowd out savings. Nevertheless, there is no empirical evidence that participating in NRSPI reduces savings, mainly because of the low level of minimum contribution chosen by most of participants (Ma and Zhou, 2014; Wang, 2017).

Liu (2019) shows that, different from the recipients, NRSPI participants reduce their fixed assets. Wang, He, and Bi (2022), however, argue that participants tend to increase fixed assets in order to reduce poverty vulnerability.

NRSPI participation also affects fertility. The number of children, as well as the probability to have the second child, are significantly lower for the participants (Shen, Zheng, and Yang, 2020). In addition, children's sex ratio at birth, measured by the number of males over the number of females, is also lower for the participants (Zhang, Li, and Hu, 2017).

3.6.3 Effects of NRSPI Implementation

The studies in this category do not distinguish participants and recipients, caring more about the effects of NRSPI implementation on the entire population of rural residents. For instance, Zheng and Zhong (2016) find that NRSPI implementation increases consumption but does not change savings of rural residents in the pilot counties. Huang and Zhang (2021) show that age-eligible individuals enjoy higher consumption, less labor supply, better health with NRSPI coverage. On the other hand, NRSPI has no effect on the age-ineligible adults.

3.7 Limitations of the Current Literature

Although the number of studies on NRSPI has been large, I find some evident limitations among them, which motivate me to conduct additional work on NRSPI. First, almost all the studies on NRSPI are descriptive or empirical, especially those evaluating NRSPI participation or effects. The only conceptual model specially designed for NRSPI is a two-period OLG model in Jiao and Jing (2014). This model is not suited to analyze either individual participation decisions or the effects of NRSPI participation on savings and consumption. It not only omits a set of individual and policy parameters, but also assumes all individuals are homogeneous. Due to the uniqueness of NRSPI, I am unable to find conceptual models in the studies on other pension schemes that are suitable for NRSPI, although they are still good references (e.g., Attanasio and Rohwedder, 2003; Beetsma, Romp, and Vos, 2012; Hsu, Yoshida, and Chen, 2022). Consequently, I proceed to develop a new conceptual model to investigate key questions regarding NRSPI.

Second, empirical findings in many studies are contradictory. Therefore, a conceptual framework is much needed to obtain testable results and provide a theoretical basis for empirical analyses.

Third, most existing simulations focus on the sustainability of NRSPI, providing no discussion about participation or policy effects (Mi, Jia, and Zhou, 2016; Wang, Huang, and Sun, 2019). Individual behaviors are neglected in these simulations as well. We need a more comprehensive simulation framework to test the findings in the conceptual framework and further explore topics related with policy effectiveness and policy efficiency of NRSPI.

Fourth, current studies focus mainly on NRSPI recipients, but pay less attention to the participants. In addition, participants are usually not divided into different age groups. To address these issues, this dissertation focuses on the behavior of potential participants and their decisions about participation and, among participants, level of contribution.

Chapter 4

Conceptual Framework

4.1 Model Setup

To help understand how rural residents make savings and NRSPI participation decisions, I develop a three-period individual decision model with uncertainty, and solve it using the method of dynamic programming. The major objective of this model is to describe how individuals choose between the two saving vehicles, i.e., private savings and NRSPI contributions, as well as how their decisions vary based on different values of factors, such as life expectancy, basic pension payment, and minimum contribution.

Consider a representative individual whose life contains at most three periods, denoted by $t = 1, 2, 3$. It is possible for the individual to die in any period, which means she does not necessarily live to period 3. Decisions are made at the start of each period to maximize the expected utility function of consumption based on the available information that the individual has.

To build connections between this model and the reality, I assume that: Period 1 is the period when the individuals are no less than 16 (the minimum age to work and to participate in NRSPI) and younger than 45 years old, i.e., $16 \leq age < 45$. Period 2 is the period when the individuals are between 45 and 60 years old, i.e., $45 \leq age < 60$. Period 3 is the period when the individuals are no less than 60 years old, i.e., $age \geq 60$.

At the start of period 1, the individual has the expected utility function over consumption in each period, denoted by c_1, c_2 and c_3:

$$u(c_1) + \beta E_1[u(c_2)] + \beta^{1+\theta} E_1[u(c_3)], \tag{4.1}$$

where $\beta \in (0,1)$ is the discount parameter from period 2 to period 1. The parameter $\theta \in (0,1)$ is fixed for each individual. Once I assume exponential discounting, the value of θ is the same for all individuals and can be calculated as $\theta = \frac{T_2}{T_1} = \frac{15}{29}$, where $T_1 = 29$ is the length of period 1, and $T_2 = 15$ is the length of period 2.[1] E_1 represents the expectation based on the information in period 1. $u(c_t)$ is increasing and strictly concave in c_t, indicating that all individuals are risk averse.

Chetty (2006) separates the agent's choices of consumption and other behaviors (such as labor supply, work effort, and portfolio purchases, etc.), and argues that other behaviors are not endogenous to the benefit level of social insurance. As a result the agent's utility function only consists of consumption. I employ this idea in my model, mainly because of two reasons. First, I have shown in Section 2.4 that most rural adults are self employed or working in the informal agricultural sector, which indicates their choices of labor supply are constrained by various factors such as climate and the particulars of crops they grow. In other words, the individuals that I am interested in cannot freely choose between labor and leisure, but, rather, are constrained by the realities of agricultural product production. Second, this simplifies the model and enables me to focus on analyzing the consumption side. Such simplification is also consistent with Jiao and Jing (2014).

At the start of period 2, the surviving individual gains new information and faces the expected utility function:

$$u(c_2) + \beta^{\theta} E_2[u(c_3)]. \tag{4.2}$$

At the start of period 3, there is no uncertainty anymore and the surviving individual

[1] Exponential discounting is the most commonly used in economics, especially in conceptual models.

has the utility function:

$$u(c_3). \tag{4.3}$$

Rural residents in China have limited access to investment, according to the CFPS data. It is plausible to assume that individuals can only move consumption between periods by either saving or contributing to NRSPI in this model. Hence, there are three components of individual income, denoted by y_t, in the presence of NRSPI program: disposable income, savings, and NRSPI benefits.

I assume that individuals are able to generate disposable income in the first two periods (denoted by g_1 and g_2, respectively), but cannot generate any in the third period (denoted by g_3, and $g_3 = 0$). Note that disposable income in this model does not include finance income. In period 1, an individual earns $g_1 = \mu_1$ with no uncertainty since g_1 is revealed to her at the start of this period. In period 2, there is a probability of ϵ ($0 < \epsilon < 1$) for the individual to suffer from a permanent negative income shock because of an income disability, denoted by $-\sigma_2$ (thus, $0 < \sigma_2 < \mu_2$). As a result, the individual gains $g_2 = \mu_2$ with the probability of $1 - \epsilon$, and $g_2 = \mu_2 - \sigma_2$ with the probability of ϵ:[2]

$$g_2 = \begin{cases} \mu_2, & probability = 1 - \epsilon; \\ \mu_2 - \sigma_2, & probability = \epsilon. \end{cases} \tag{4.4}$$

Since the exact state of g_2 is revealed at the start of period 2, it is unknown to the individual when she is making decisions at the start of period 1, which introduces uncertainty to this model.

Individuals can save a non-negative amount of money in the first two periods, denoted by s_1 and s_2 (thus, $s_3 = 0$). The long-term savings interest rates in period 1 and 2 are denoted by r_1 and r_2, respectively. Then, savings equaling s_t in period t will turn into income equaling $(1 + r_t)s_t$ in period $t + 1$, where t can be 1 and 2.

[2]For the individuals who die before period 2, I assume $g_2 = \mu_2 = \sigma_2 = 0$, which can also be represented by equation (4.4).

Individuals make NRSPI participation and contribution decisions for the first two periods, and receive NRSPI benefits in period 3, if they have met the minimum contribution requirement. Thus, there is no overlap between making contributions and receiving benefits. Whenever individuals are indifferent between not participating and participating, they will choose the former.

Based on my assumptions, participation in either period 1 or period 2 alone will be sufficient for the individual gain the eligibility for NRSPI benefits. In reality, individuals are able to stop contributing in some years and resume contributions later, although the contribution gap cannot be too long. What is more, contribution level can vary across years. As a result, it will be more convenient and feasible to develop the model with multiple years in a period, which allows me to not consider annual decisions and to focus on aggregated contributions.

Letting NRSPI contributions in period 1 and 2 be p_1 and p_2 (thus, $p_3 = 0$), I have the minimum contribution constraint:

$$p_1 + p_2 \geq M, \tag{4.5}$$

where M is the minimum total contribution for NRSPI eligibility. The maximum level of NRSPI contribution also exists in reality, but including it makes p_1 and p_2 totally discrete with only three possible values (zero, minimum contribution, and maximum contribution). To better show the trade-off between savings and contribution, I do not include the maximum contribution. Actually, introducing the maximum contribution does not affect NRSPI participation decisions under my model assumptions. All the contributions go to individual NRSPI account and cannot be withdrawn at any time. Similar to savings, there are constant interest rates in each period for NRSPI account balance, denoted by r_{p1} and r_{p2}, respectively.

Compared with savings, NRSPI benefits in period 3 are more complicated in terms of calculation. Before I present the equation for NRSPI benefits, let me define two important parameters. First, the basic pension parameter, a, is defined as:

$$a = k \times T, \tag{4.6}$$

where k is the monthly basic pension payment, and T (in months) is policy-specified life span after reaching age 60. Currently, the uniform value of T equals 139, and the minimum value of k suggested by the central government is 55 yuan. Based on this definition, a represents the total amount of basic pension benefits received in T months after reaching 60.[3]

Second, the life expectancy parameter, b, is defined as:

$$b = \begin{cases} 0, & LE < 60; \\ \frac{12(LE-60)}{T}, & LE \geq 60, \end{cases} \tag{4.7}$$

where LE (in years) is the life expectancy at age 16, since the minimum age requirement for eligibility is 16 years old.[4] Thus, b is the ratio of months lived after 60 years old (i.e., $12(LE - 60)$) and policy-specified span (i.e., T). Based on the definition of b, I assume that individuals are heterogeneous in terms of life expectancy. $b = 0$ suggests the individual does not live to 60 years old. $0 < b < 1$ means the individual dies before her individual account balance is exhausted. And $b \geq 1$ indicates the individual dies after her individual account balance is exhausted. The model will be developed with and without assuming that individuals are perfectly foresighted, which means they know exactly how long they will live (i.e., they know the exact values of LE). Different assumptions about life expectancy foresight lead to different optimization problems, which I will discuss later in this dissertation.

With the two parameters well defined, I obtain NRSPI benefits in period 3, denoted by

[3] It is worth noting that, although k and a both refer to basic pension benefits, they have different meanings and usages. The former refers to monthly basic pension benefits, and the latter refers to total basic pension benefits received in the government specified life span. The value of a is dependant on k and T, and is created mostly for the convenience of derivations and comparative statics. A similar statement can be applied to the life expectancy parameter, i.e., b.

[4] It also implies that $LE \geq 16$.

$B(p_1, p_2)$, in the following equation:[5]

$$B(p_1, p_2) = \begin{cases} 0, & p_1 + p_2 < M; \\ b[a + (1 + r_{p1})(1 + r_{p2})p_1 + (1 + r_{p2})p_2], & p_1 + p_2 \geq M. \end{cases} \tag{4.8}$$

When $p_1 + p_2 \geq M$, $B(p_1, p_2)$ can be re-written as $12(LE - 60)[k + \frac{(1+r_{p1})(1+r_{p2})p_1+(1+r_{p2})p_2}{T}]$, where $k + \frac{(1+r_{p1})(1+r_{p2})p_1+(1+r_{p2})p_2}{T}$ is the fixed amount of NRSPI benefits received each month from both basic and individual accounts. As long as the individual is alive, she always receive the same amount even her individual account balance falls to zero after T months.

Finally, I assume that individuals are endowed with different levels of initial wealth, denoted by w_0. The time line of the entire model can be described as follows. At the start of period 1, initial wealth w_0 is given and disposable income g_1 is revealed, and then individuals decide s_1, p_1, and c_1 to allocate cash on hand that consists of disposable income and initial wealth. At the start of period 2, disposable income g_2 is revealed, and then individuals decide s_2, p_2, and c_2 to allocate cash on hand that consists of disposable income, savings and interest. In period 3, individuals simply consume all the cash on hand that consist of pension benefits, savings, and interest, the amount of which is denoted by c_3.

Note that I currently ignore bequests in this conceptual framework. It will be a reasonable assumption if the proportion of bequests are low enough compared to consumption. Some may argue that traditional Chinese culture encourages rural parents to leave as large bequests as possible to their children (e.g., Ebenstein and Leung, 2010; Yang and Gan, 2020). However, Ang (2009) argues that household savings are negatively correlated with expected pension benefits in China, indicating that pension benefits at least lower bequest motives. Hu, Xu, and Zhang (2020) further show that Chinese seniors tend to leave fixed housing assets as bequests but utilize financial assets, including savings and pension income, as living consumption. Han, Wang, and Dong (2020) also indicate that bequest motives for Chinese

[5]It is interesting to note that individuals die before 60 will surely receive no NRSPI benefit.

seniors are decreasing with the development of reverse mortgage. Alternatively, I can assume that individuals leave a portion of cash on hand unconsumed in period 3 due to bequest motives. I will show that, under the assumption of logarithm utility functions, neither participation decisions nor optimal consumption and savings in the first two periods are likely to change. Henceforth, I do not take bequests into consideration.

Based on the assumptions, individuals receive initial wealth and generate disposable income in period 1. Hence, individual income in period 1, y_1, is:

$$y_1 = g_1 + w_0. \tag{4.9}$$

Individual income in period 2, y_2, consists of disposable income and savings in period 1:

$$y_2 = g_2 + (1 + r_1)s_1. \tag{4.10}$$

Individual income in period 3, y_3, comes from savings in period 2 and NRSPI benefits depending on the values of p_1 and p_2:

$$y_3 = (1 + r_2)s_2 + 1\{p_1 + p_2 \geq M\}b[a + (1 + r_{p1})(1 + r_{p2})p_1 + (1 + r_{p2})p_2]. \tag{4.11}$$

The indicator function $1\{p_1 + p_2 \geq M\}$ equals 1 if $p_1 + p_2 \geq M$, and equals 0 otherwise.

4.2 Simplification

In order to obtain more interpretable results of comparative statics, it will be helpful for me to consider a simpler version of the model. Therefore, I make several important assumptions to simplify the model that I have set up:

(1) My general model assumes that individuals have different initial wealth (i.e., w_0) and revealed disposable income (i.e., g_1) at the start of period 1, which sum up to be the "cash on hand" in period 1. Therefore, I can combine g_1 and w_0 as the variable of "cash on hand" in period 1, denoted by I_1:

$$I_1 = g_1 + w_0. \tag{4.12}$$

(2) I normalize the long-term savings rates by taking the differences between long-term market savings rates and the interest rates for the NRSPI individual account. Thus, I calculate $r_1 = r_1^m - r_{p1} > 0$, and $r_2 = r_2^m - r_{p2} > 0$. This is a reasonable assumption since the annual interest rate for NRSPI individual account usually equals the lowest one-year savings deposit rate provided by the financial institutions, implying that $r_{p,i} < r_i^m$ $(i = 1, 2)$. Besides, NRSPI cannot control the market savings rate, but is able to adjust NRSPI interest rate. As a result the normalized savings rates are subject to NRSPI policy changes. Under this assumption, I can get rid of $r_{p,i}$ in the derivations, but need to be aware that increasing $r_{p,i}$ will lead r_i to decrease.[6]

(3) To derive closed-form solutions that can be used for comparative static analyses and the subsequent simulation, I specify the logarithm functional form of utility that implies decreasing absolute risk aversion (DARA), and constant relative risk aversion (CRRA), to allow for further derivations:[7]

$$u(c_t) = ln(c_t). \tag{4.13}$$

Based on the simplifications above, the optimization problem for the representative individual in period 3 becomes:

$$\max_{c_3} \; ln(c_3), \tag{4.14}$$

[6]Henceforth, r_1 and r_2 both refer to normalized savings rates unless stated otherwise.

[7]A number of studies on the pension schemes, e.g., Bodie, Marcus, and Merton (1988), Catalan and Magud (2012), and Yang and Zhou (2017), also employ logarithm utility functions. CRRA is widely accepted as reflective of risk behavior, and is widely used in developing-country studies (Tanaka, Camerer, and Nguyen, 2010; Ahmed, Haider, and Iqbal, 2012; Liu, 2013). Saitone, Sexton, and Malan (2018) point out that the coefficient of relative risk aversion for a CRRA specification is a unit-free elasticity, which enables me to compare estimates across studies directly.

subject to the conditional budget constraint:

$$c_3 \le \begin{cases} (1+r_2)s_2, & p_1 + p_2 < M; \\ (1+r_2)s_2 + b(a + p_1 + p_2), & p_1 + p_2 \ge M. \end{cases} \tag{4.15}$$

And the optimization problem in period 2 is:

$$\max_{c_2, s_2, p_2} ln(c_2) + \beta^{\theta} E_2[ln(c_3)], \tag{4.16}$$

subject to the budget constraint:

$$c_2 + s_2 + p_2 \le g_2 + (1 + r_1)s_1. \tag{4.17}$$

Finally the optimization problem in period 1 is:

$$\max_{c_1, s_1, p_1} ln(c_1) + \beta E_1[ln(c_2)] + \beta^{1+\theta} E_1[ln(c_3)], \tag{4.18}$$

subject to the budget constraint:

$$c_1 + s_1 + p_1 \le I_1. \tag{4.19}$$

The expectation operator E_t denotes the fact that the expectation is conditional on information available at the beginning of period t. Therefore, E_1 is different from E_2 in terms of the sources of uncertainty.

Since the budget constraint must be binding in the consumer optimum, i.e., the optimum is on the budget line, I can replace the inequality signs with equal signs in equations (4.19), (4.17), and (4.15), and then eliminate the consumption choice variable (i.e., c_t) in the following derivations. To be specific, I replace c_1 with $I_1 - s_1 - p_1$, replace c_2 with $g_2 + (1 + r)s_1 - s_2 - p_2$, and replace c_3 with $(1 + r)s_2 + 1\{p_1 + p_2 \ge M\}b(a + p_1 + p_2)$.

Now I am able to obtain some interesting results, as described below, that will be important to simplify and guide my derivations. We need be aware that bequest motives will not influence the following results.

Result 1: The optimal value of p_1 will always be 0.

Let us suppose we have the solution $p_1 = d > 0$. If I reduce p_1 to 0 and increase both s_1 and p_2 by d, c_1 will not change while $\Delta c_2 + \Delta s_2 = (1 + r_1)\Delta s_1 - \Delta p_2 = r_1 d > 0$. Noticing that the value of $p_1 + p_2$ also stays constant, at least one of c_2 and c_3 (or both) can increase. Then the entire life-time utility for the individual will increase as well. As a result, we always have $p_1 = 0$. Individuals will never contribute to NRSPI in period 1 (i.e., before 45 years old) when there is no incentive subsidy to the NRSPI individual account that rewards longer years of contribution.

Result 2: If not participating, the individual will contribute $p_2 = 0$.

At the start of period 2, the individual will choose to contribute nothing to NRSPI if she decides not to participate. It is because the NRSPI individual account balance cannot be withdrawn at any time, making any positive amount of contribution lower than M economically unbeneficial. Even if the balance could be withdrawn, it is sufficient for non-participants to contribute nothing since $r_2 > 0$.

Result 3: If participating, the optimal value of p_2 depends on the comparison between $1+r_2$ and b.

Now I focus on the individual who chooses to participate in NRSPI. Suppose we have the solution for optimization $p_2 = M + d$, where $d > 0$. If I reduce p_2 to M, we have $\Delta p_2 = -d$. Once I keep c_1 and c_2 constant, I only need to discuss the sign of Δc_3. Hence, I increase s_2 by $\Delta s_2 = -\Delta p_2 = d$. So $\Delta c_3 = (1 + r_2)d - bd = (1 + r_2 - b)d$, whose sign depends on the comparison between $1 + r_2$ and b. If $1 + r_2 \geq b$, we know $\Delta c_3 \geq 0$, which means $p_2 = M$ and $s_2 > 0$ lead to the higher utility. If $1 + r_2 < b$, we have $\Delta c_3 < 0$, which means $p_2 > M$ and $s_2 = 0$ yield the higher utility. Therefore, we have either $p_2 = M$ (correspondingly $s_2 > 0$) or $s_2 = 0$ (correspondingly $p_2 > M$) in period 2 for those who opt in NRSPI. Individuals are willing to contribute more than the minimum amount of money only when they expect to live long enough.

Result 4: If $1 + r_2 \geq b$, the participation decision depends on the comparison between $(1 + r_2)M$ and $b(a + M)$ assuming interior solutions.

Since $1 + r_2 \geq b$, I learn from the previous discussion that $p_2 = M$ if participating and $p_2 = 0$ if not participating. Suppose we initially have $p_2 = M$ and $s_2 > 0$. If I reduce p_2 to 0, i.e., $\Delta p_2 = -M$, and increase s_2 by $\Delta s_2 = M$, we know c_1 and c_2 will stay constant, and $\Delta c_3 = (1+r_2)M - b(a+M)$. Therefore, if $(1+r_2)M \geq b(a+M)$, $\Delta c_3 \geq 0$ and the individual will choose not to participate in NRSPI; if $(1+r_2)M < b(a+M)$, $\Delta c_3 < 0$ and the individual will choose to participate in NRSPI. However, we need to be aware that this conclusion is only valid if initial s_2 is larger than zero, and there does not exist a $\Delta s_2 = d \in (0, M)$ which leads to an increase of the utility in period 2 overpowering the decrease of utility in period 3. Otherwise, it is an example of corner solutions which I will discuss in detail later. This conclusion implies that, as long as the basic pension payment is high enough, individuals with low life expectancy will also participate in NRSPI.

Result 5: If $1 + r_2 < b$, the individual will always participate in NRSPI.

Since $1 + r_2 < b$, we know $p_2 = d > M$ and $s_2 = 0$ if participating, and $p_2 = 0$ and $s_2 > 0$ if not participating. Suppose the individual switches from participating to not participating, I can reduce p_2 to 0, i.e., $\Delta p_2 = -d$, and increase s_2 by $\Delta s_2 = d$. Then it is evident that c_1 and c_2 will stay constant, and $\Delta c_3 = (1 + r_2)d - (ba + bd) < (1 + r_2)d - bd < 0$. Therefore, individuals with adequately high life expectancy will always choose to participate in NRSPI. Similar with the previous subsection, the premise for this conclusion to be valid is that the sub-optimal value for s_2 when p_2 decreases from d to M is larger than zero. In other words, I need to exclude special cases of corner solutions.

Result 6: Individuals with life expectancy no greater than 60 will never participate in NRSPI.

This conclusion comes directly from the conclusions above. By definition, individuals with life expectancy no greater than 60 have life expectancy parameter $b = 0$, which means $1 + r_2 > b$ and $(1 + r_2)M > b(a + M)$ are always satisfied. As a results, these individuals will never contribute to NRSPI.

4.3 Optimization

I now solve the optimization problem using the simplified model. I will first discuss the case where individuals are perfectly foresighted, then introduce the uncertainty about life expectancy and show how it affects decisions.

4.3.1 Individuals with Perfect Foresight

Following the idea of dynamic programming, I start with period 3. Since we always have corner solution for p_1, i.e., $p_1 = 0$, I eliminate p_1 in the following derivations. Thus, total NRSPI contribution is equal to p_2.

4.3.1.1 Period 3

If the individual does not live to period 3, i.e., $b = 0$, there is no longer utility maximizing decision making in period 3, and her utility in period 3 is zero.

If the individual's life expectancy exceeds 60, i.e., $b > 0$, she simply consumes whatever she has in period 3. Given that the budget constraint (4.15) binds in period 3, I derive:

$$c_3^* = (1 + r_2)s_2 + 1\{p_2 \geq M\}b(a + p_2), \tag{4.20}$$

or equivalently:

$$c_3^* = \begin{cases} (1 + r_2)s_2, & p_2 < M; \\ (1 + r_2)s_2 + b(a + p_2), & p_2 \geq M. \end{cases} \tag{4.21}$$

Therefore, the utility function in period 3 can be represented by:

$$u(c_3^*) = ln[(1 + r_2)s_2 + 1\{p_2 \geq M\}b(a + p_2)]. \tag{4.22}$$

If I consider the effects of bequest motives, I need to assume the individual only consumes a part of cash on hand in period 3 and leaves some as bequests. Letting this proportion of consumption be α ($0 < \alpha < 1$), consumption in period 3 for the individual becomes (the utility function will also change accordingly):

$$c_3^* = \alpha[(1 + r_2)s_2 + 1\{p_2 \geq M\}b(a + p_2)]. \tag{4.23}$$

4.3.1.2 Period 2: Optimization

Now I go back to period 2. I solve the optimization problem mathematically first, then utilize graphs to illustrate the effects of parameter changes on individual participation decisions. Similar with the case in period 3, there is no decision making and s_2^*, p_2^* and c_2^* are all equal to 0 if the individual does not live to period 2.

If the individual lives to period 2 but will not live to period 3, i.e., has life expectancy between 45 and 60, she will consume all cash on hand, not saving or contributing anything:

$$s_2^* = p_2^* = 0, \tag{4.24}$$

$$c_2^* = g_2 + (1 + r_1)s_1. \tag{4.25}$$

Since s_1 and g_2 are exogenous to the individual when making decisions in period 2, I define the value function in period 2 as $W_2(s_1, g_2)$, which measures the indirect lifetime utility maximized by given values of s_1 and g_2. Then, the maximized utility for the individual who dies in period 2 is represented as:

$$W_2(s_1, g_2) = ln[g_2 + (1 + r_1)s_1]. \tag{4.26}$$

For the individual whose life expectancy exceeds 60, optimization is more complicated since she needs to take period 3 into consideration. Plugging in the binding budget constraint

(4.17) and eliminating c_2, I obtain the optimization problem faced by the individual:

$$W_2(s_1, g_2) = \max_{s_2, p_2} \ ln[g_2 + (1+r_1)s_1 - p_2 - s_2] + \beta^\theta ln[(1+r_2)s_2 + 1\{p_2 \geq M\} b(a+p_2)]. \quad (4.27)$$

No expectation operator appears in equation (4.27) since period 3 contains no new information. Then I need to discuss case by case since $u(c_3)$ takes different functional forms based on the value of p_2.

(1) Group 1: Not Participating

If the individual decides not to participate in NRSPI after information in period 2 is revealed, she contributes nothing in period 2. Thus, $p_2 = 0$. The optimization problem can be simplified to:

$$W_2(s_1, g_2) = \max_{s_2} \ ln[g_2 + (1 + r_1)s_1 - s_2] + \beta^\theta ln[(1 + r_2)s_2]. \quad (4.28)$$

The first-order condition w.r.t. s_2 is:

$$\frac{1}{g_2 + (1 + r_1)s_1 - s_2} = \frac{\beta^\theta}{s_2}. \quad (4.29)$$

From equation (4.29) I can solve for optimal s_2:

$$s_2^* = \frac{\beta^\theta g_2 + \beta^\theta (1 + r_1)s_1}{1 + \beta^\theta}. \quad (4.30)$$

Consumption in period 2 is therefore:

$$c_2^* = g_2 + (1 + r_1)s_1 - s_2^* = \frac{g_2 + (1 + r_1)s_1}{1 + \beta^\theta}. \quad (4.31)$$

Plugging s_2^* into $W_2(s_1, g_2)$, the first-order partial derivative of $W_2(s_1, g_2)$ w.r.t. s_1 is:[8]

$$\frac{\partial W_2(s_1, g_2)}{\partial s_1} = \frac{(1+\beta^\theta)(1+r_1)}{g_2 + (1+r_1)s_1}, \tag{4.32}$$

based on which we can see the maximized utility in period 2 is increasing in the savings in period 1. For a given level of s_1, the marginal utility increase stemming from savings is positively related with the discount parameter and normalized savings rate in period 1, but is negatively related with revealed income in period 2.

From the perspective of the relationship between period 2 and period 3 consumption, I derive the intertemporal budget constraint for the individuals that choose not to participate (denoted by **Group 1** henceforth) from the binding constraints in period 2 and 3, namely $c_2 + s_2 = g_2 + (1+r_1)s_1$ and $c_3 = (1+r_2)s_2$:

$$c_3 = (1+r_2)[g_2 + (1+r_1)s_1] - (1+r_2)c_2. \tag{4.33}$$

Now I am able to graphically present the intertemporal budget constraint in Figure 4.1. As we can observe, the slope of the budget line is $-(1+r_2)$. In order to find optimal values for c_2 and c_3, I draw indifference curves. The slope of an indifference curve in this case is:

$$\frac{dc_3}{dc_2} = -MRS_{c_2,c_3} = -\frac{MU_{c_2}}{MU_{c_3}} = -\frac{\partial ln(c_2) + \beta^\theta ln(c_3)}{\partial c_2} \Big/ \frac{\partial ln(c_2) + \beta^\theta ln(c_3)}{\partial c_3} = -\frac{1}{\beta^\theta}\frac{c_3}{c_2}, \tag{4.34}$$

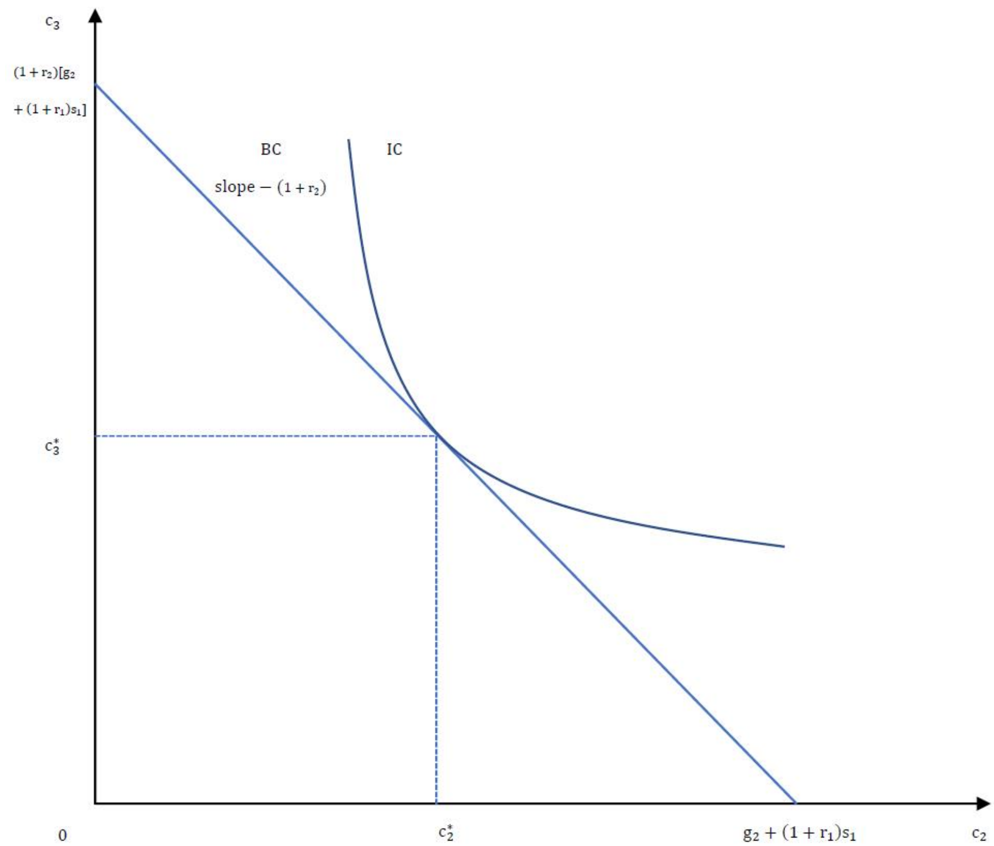
where MRS_{c_2,c_3} is the marginal rate of substitution between c_2 and c_3, and MU_{c_2}, MU_{c_3} are marginal utilities.

To maximize utility, I need to find the indifference curve that is tangent to the budget line, as is illustrated in Figure 4.1. The optimal values at the point of tangency can be solved by the following equation:

$$-(1+r_2) = -\frac{1}{\beta^\theta}\frac{c_3^*}{c_2^*}, \tag{4.35}$$

[8] I can also obtain the same result by applying the envelope theorem.

Figure 4.1: Intertemporal Budget Constraint between Period 2 and 3 for Individuals not Participating in NRSPI



which yields $c_3^* = \beta^\theta(1+r_2)c_2^*$, or equivalently $\frac{c_3^*}{c_2^*} = \beta^\theta(1+r_2)$. The greater β or r_2 is, the higher c_3^* is relative to c_2^*. Plugging this relationship in equation (4.33), I obtain exactly the same optimal consumption as equation (4.31).

Since NRSPI has no effect in this case, it can also serve as the base case without the implementation of NRSPI, which is helpful in the following comparative static analysis.

If I introduce bequest motives, the optimization problem becomes:

$$W_2(s_1, g_2) = \max_{s_2} \; ln[g_2 + (1+r_1)s_1 - s_2] + \beta^\theta ln[\alpha(1+r_2)s_2]. \tag{4.36}$$

Nevertheless, the first-order condition is still equation (4.29), and the following derivations are not affected at all. Therefore, with the logarithm utility function, assuming bequest motives does not change the optimal values for Group 1 in period 2 and period 1 (which is obvious since $\frac{\partial W_2(s_1,g_2)}{\partial s_1}$ stays the same). This conclusion can be applied to all the other groups, and I do not elaborate again.

(2) Group 2: Participating at the Minimum Contribution

If the individual decides to participate, we must have $(1+r_2)M < b(a+M)$ and $p_2 \geq M$. So the optimization problem becomes:

$$W_2(s_1, g_2) = \max_{s_2,p_2} \; ln[g_2 + (1+r_1)s_1 - p_2 - s_2] + \beta^\theta ln[(1+r_2)s_2 + b(a+p_2)]. \tag{4.37}$$

The two first-order conditions w.r.t. s_2 and p_2 are:

$$\frac{\beta^\theta(1+r_2)}{(1+r_2)s_2 + b(a+p_2)} \leq \frac{1}{g_2 + (1+r_1)s_1 - p_2 - s_2}, \tag{4.38}$$

$$\frac{\beta^\theta b}{(1+r_2)s_2 + b(a+p_2)} \leq \frac{1}{g_2 + (1+r_1)s_1 - p_2 - s_2}. \tag{4.39}$$

Comparing FOCs (4.38) and (4.39), we know they cannot be binding at the same time unless $1 + r_2 = b$. Without loss of generality, I assume individuals contribute $p_2 = M$ in this special case. Based on the previous argument, one of the following conditions must be satisfied if I assume interior solutions:

i. Equation (4.38) is binding while equation (4.39) is not if $1+r_2 \geq b$. Then the individual contributes at the minimum level in period 2, i.e., $p_2^* = M$.

ii. Equation (4.39) is binding while equation (4.38) is not if $1 + r_2 < b$. Then the individual saves nothing in period 2, i.e., $s_2^* = 0$.

I first consider the case where $1 + r_2 \geq b$. Letting FOC (4.38) be binding and applying $p_2^* = M$ to it, I obtain the following equation:

$$\frac{\beta^\theta(1+r_2)}{(1+r_2)s_2 + b(a+M)} = \frac{1}{g_2 + (1+r_1)s_1 - M - s_2}. \tag{4.40}$$

From equation (4.40) I can solve for optimal s_2:

$$s_2^* = \frac{\beta^\theta(1+r_2)(g_2+(1+r_1)s_1) - \beta^\theta(1+r_2)M - b(a+M)}{(1+\beta^\theta)(1+r_2)}. \tag{4.41}$$

Consumption in period 2 is therefore:

$$c_2^* = g_2 + (1+r_1)s_1 - M - s_2^* = \frac{(1+r_2)(g_2+(1+r_1)s_1) + b(a+M) - (1+r_2)M}{(1+\beta^\theta)(1+r_2)}. \tag{4.42}$$

Then I apply equations (4.41) and (4.42) to $W_2(s_1, g_2)$ in equation (4.37), and take the first-order partial derivative of $W_2(s_1, g_2)$ w.r.t. s_1:

$$\frac{\partial W_2(s_1, g_2)}{\partial s_1} = \frac{(1+\beta^\theta)(1+r_1)(1+r_2)}{(1+r_2)(g_2+(1+r_1)s_1) + b(a+M) - (1+r_2)M}, \tag{4.43}$$

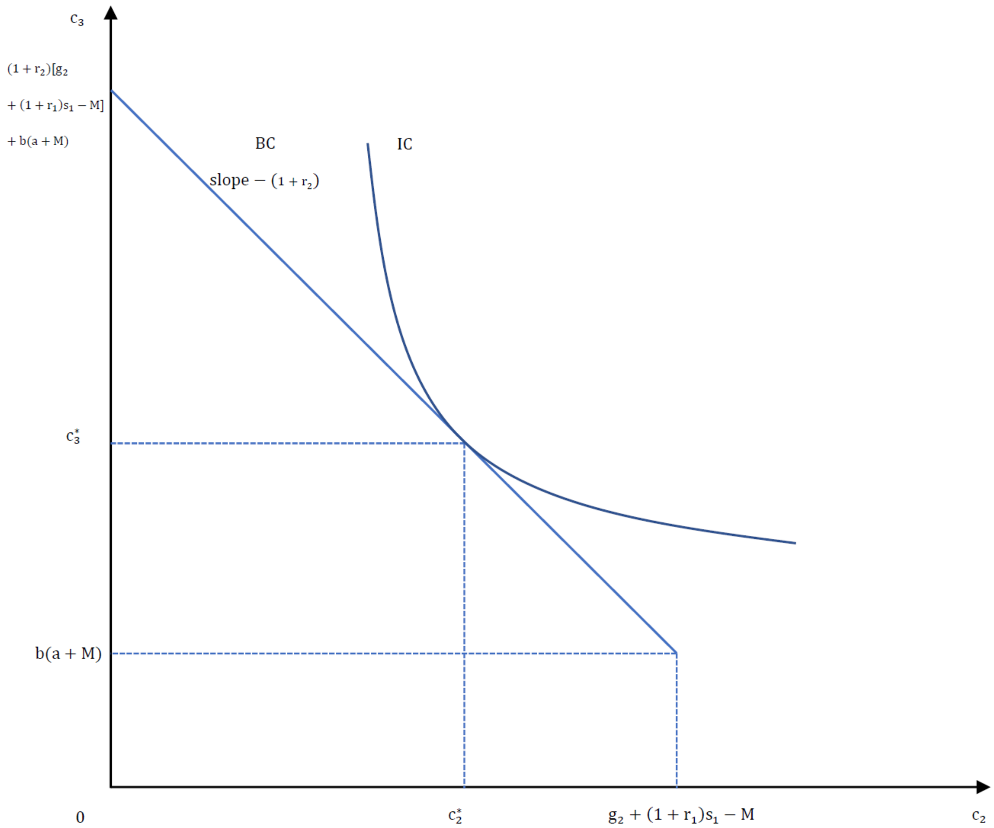
from which we know that the maximized utility in period 2 is increasing in savings in period 1. For a given s_1, the marginal utility increase stemming from savings is positively related with the discount parameter, minimum total contribution, specified life span after 60, and normalized savings rates, but negatively related with revealed income in period 2, life expectancy, and basic pension payment.

I can also solve this optimization problem with the help of the intertemporal budget constraint. Combining binding budget constraints $c_2 + s_2 + M = g_2 + (1+r_1)s_1$ and $c_3 = (1+r_2)s_2 + b(a+M)$, I replace s_2 with c_2 and obtain the intertemporal budget constraint for the individuals who choose to contribute at the minimum level (denoted by **Group 2** henceforth):

$$c_3 = (1+r_2)[g_2 + (1+r_1)s_1] - (1+r_2)M + b(a+M) - (1+r_2)c_2. \tag{4.44}$$

Figure 4.2 illustrates this intertemporal budget constraint. The slope of the budget line is the same as Group 1, but the intercepts are larger. In the meanwhile, the derivation

Figure 4.2: Intertemporal Budget Constraint between Period 2 and 3 for Individuals Participating at the Minimum Contribution



of indifference curves is not affected by participation decisions, resulting in the same slope for an indifference curve, i.e., $-\frac{1}{\beta^\theta}\frac{c_3}{c_2}$. Therefore, I can still obtain the similar relationship between c_3 and c_2: $c_3^* = \beta^\theta(1+r_2)c_2^*$. Plugging back in equation (4.44), I obtain the same optimal value as equation (4.42).

It is worth noting that my derivations implicitly assume there is no corner solution for s_2^* (thus, $s_2^* = 0$), or equivalently, $1 + r_2 \geq b$ and $(1 + r_2)M < b(a + M)$ are the necessary and sufficient conditions for the individuals to participate at minimum contribution. While the necessity is evident and has been proven in Section 4.2, the sufficiency is not yet clear. In order to make sure I have an interior solution for s_2^*, I need an extra condition that $\beta^\theta(1+r_2)(g_2+(1+r_1)s_1-M) \geq b(a+M)$, which is equivalent to $M \leq \frac{\beta^\theta(1+r_2)(g_2+(1+r_1)s_1)-ba}{\beta^\theta(1+r_2)+b} = M'$. As b increases, M' gradually decreases and corner solutions are more likely to occur.

Based on the definition, we know there exists a value larger than M', denoted by M'', that makes the individual indifferent between i) participating in NRSPI by contributing at the minimum and saving nothing, and ii) not participating. Since $(1 + r_2)M < b(a + M)$ can be reorganized as $M < \frac{ab}{1+r_2-b}$, I obtain the conclusion by comparing M'' and $\frac{ab}{1+r_2-b}$. Whenever M'' is larger than $\frac{ab}{1+r_2-b}$, $1+r_2 \geq b$ and $(1+r_2)M < b(a+M)$ will be the sufficient conditions for the individual to participate in NRSPI at minimum contribution. Otherwise, there will be at least an M that satisfies $(1 + r_2)M < b(a + M)$ but leads the individual to not participate in NRSPI.

(3) Group 3: Participating beyond the Minimum Contribution

Now I consider the case where $1 + r < b$. It is clear that $s_2^* = 0$. Binding FOC (4.39), I obtain the following equation:

$$\frac{\beta^\theta}{a + p_2} = \frac{1}{g_2 + (1 + r_1)s_1 - p_2}. \tag{4.45}$$

From equation (4.45) I can solve for optimal p_2:

$$p_2^* = \frac{\beta^\theta(g_2 + (1 + r_1)s_1) - a}{1 + \beta^\theta}. \tag{4.46}$$

Consumption in period 2 is therefore:

$$c_2^* = g_2 + (1 + r_1)s_1 - p_2 = \frac{g_2 + (1 + r_1)s_1 + a}{1 + \beta^\theta}. \tag{4.47}$$

And I derive:

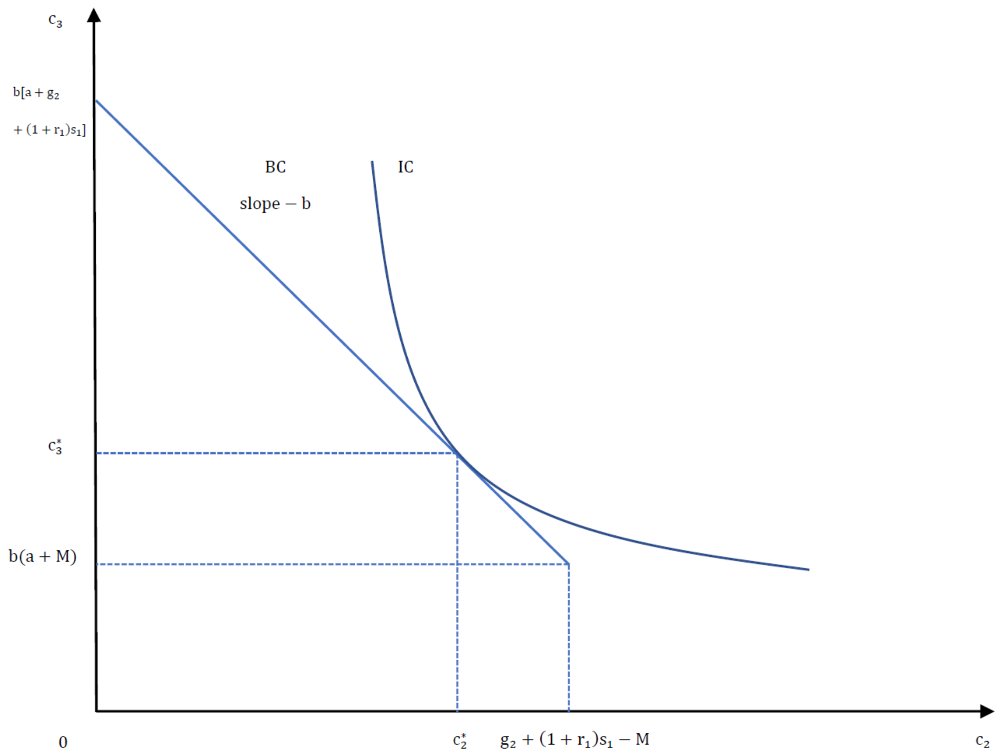
$$\frac{\partial W_2(s_1, g_2)}{\partial s_1} = \frac{(1 + \beta^\theta)(1 + r_1)}{g_2 + (1 + r_1)s_1 + a}, \tag{4.48}$$

which leads me to conclude that the maximized utility in period 2 is increasing in savings in period 1. For a given s_1, the marginal utility increase stemming from savings is positively related with the discount parameter and normalized savings rate in period 1, but negatively related with revealed income in period 2 , monthly basic pension payment, and specified life span. Besides, life expectancy parameter has no direct impact on optimal values in period 2 for Group 3, although optimal consumption in period 3 changes with life expectancy.

Using binding budget constraints $c_2 + p_2 = g_2 + (1 + r_1)s_1$ and $c_3 = b(a + p_2)$, I derive the intertemporal budget constraint for the individuals who participate in NRSPI by contributing beyond the minimum (denoted by **Group 3** henceforth):

$$c_3 = b[g_2 + (1 + r_1)s_1 + a] - bc_2. \tag{4.49}$$

Figure 4.3: Intertemporal Budget Constraint between Period 2 and 3 for Individuals Participating beyond the Minimum Contribution



I depict this intertemporal budget constraint in Figure 4.3. The slope for the budget line is $-b$ instead of $-(1 + r_2)$. On the other side, the slope of indifference curves remains the same, which is $-\frac{1}{\beta^\theta}\frac{c_3}{c_2}$. At optimum, the two slopes are equal:

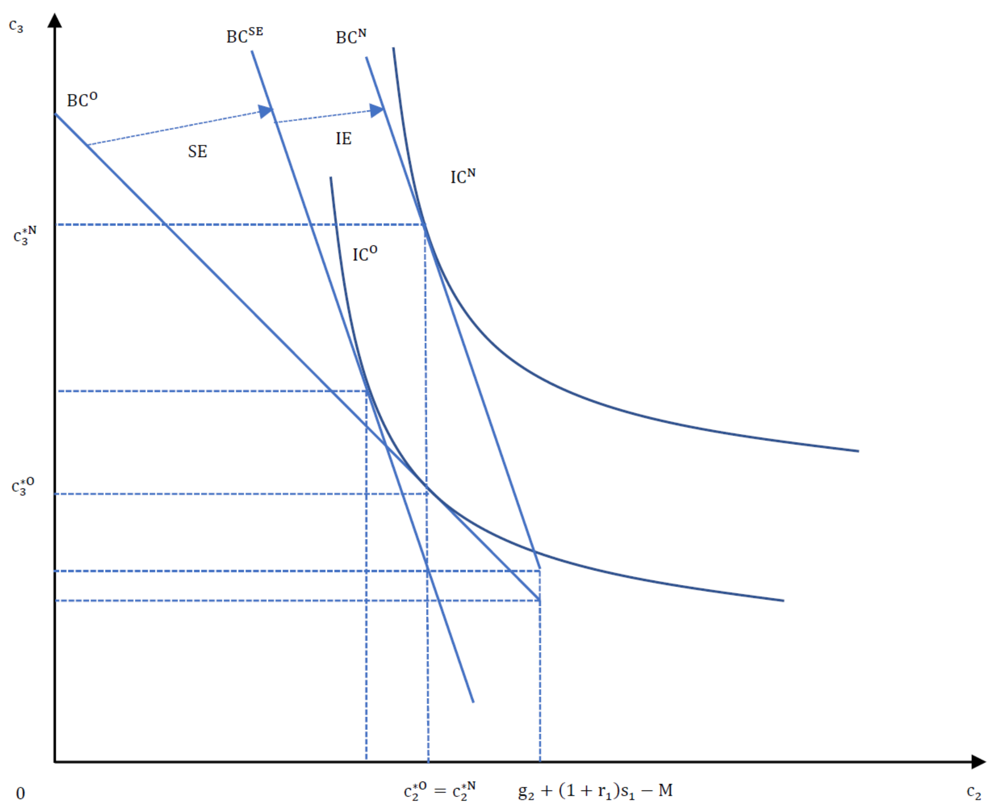
$$b = -\frac{1}{\beta^\theta}\frac{c_3^*}{c_2^*}, \tag{4.50}$$

which yields $c_3^* = \beta^\theta bc_2^*$. The ratio of c_3^* to c_2^* is now positively correlated with β^θ and

b. Replacing c_3 with $\beta^\theta b c_2$ in equation (4.49), I solve for optimal c_2 which is identical to equation (4.47).

It is of great interest to notice that c_2^* and p_2^* is irrelevant with b and therefore life expectancy, which means a higher value of b simply increases c_3^* while c_2^* always remains constant. This result stems from the assumption of logarithm utility functions. Once life expectancy increases, b increases correspondingly. The substitution effect will rotate original intertemporal budget constraint BC^O counter-clockwise to BC^{SE} in Figure 4.4, which is still tangent to original indifference curve IC^O, since c_2 becomes less favored compared with c_3. On the other hand, the income effect will translate BC^{SE} upwards to BC^N, since cash on hand in period 3 is higher, ceteris paribus. The tangent indifference curve then switchs from IC^I to IC^N.

Figure 4.4: Substitution and Income Effects When life expectancy Increases for Individuals Participating beyond the Minimum Contribution

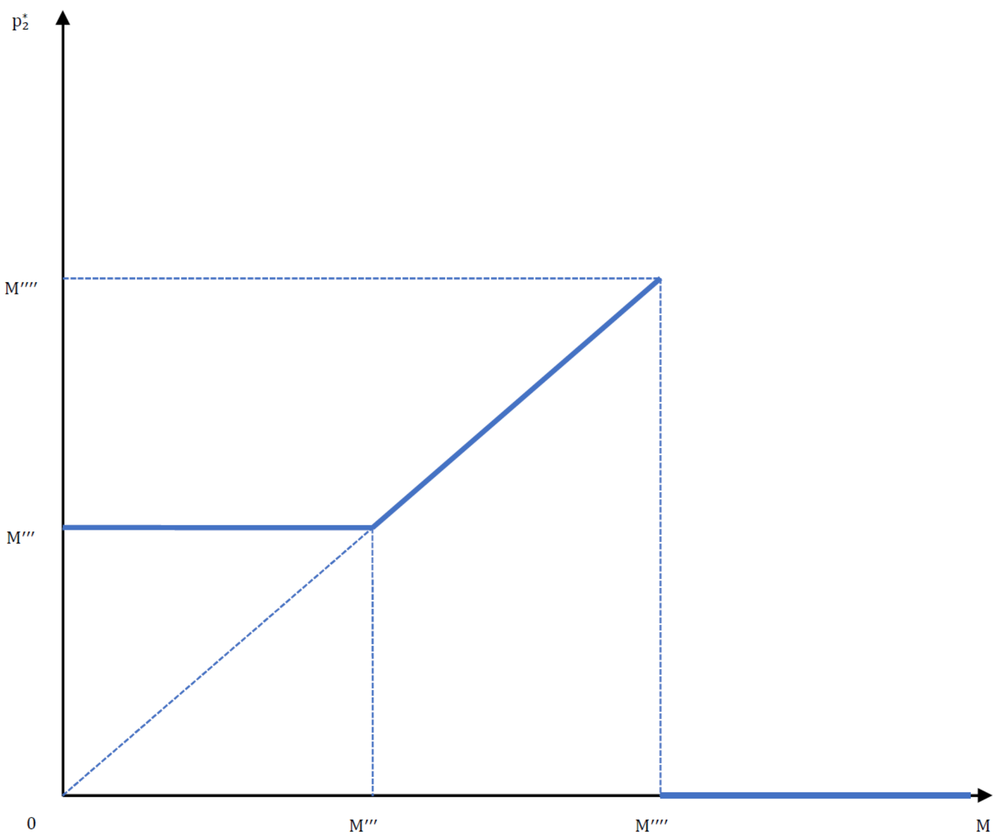


While the income effect encourages more consumption in period 2, the substitution effect reduces it. Under the assumption of logarithm utilities, these two effects perfectly cancel out, resulting in the same value of c_2^*. No matter how long an individual in group 3 expects to live, her consumption and contribution in period 2 remain unchanged if other parameters are the same.

Furthermore, to ensure that there is an interior solution for p_2^*, we require $\beta^\theta(g_2 + (1 + r_1)s_1) - a \geq (1 + \beta^\theta)M$. Similar with group 2, $M''' = \frac{\beta^\theta(g_2+(1+r_1)s_1)-a}{1+\beta^\theta}$ is the value that satisfies the equation:

$$\beta^\theta(g_2 + (1 + r_1)s_1) - a = (1 + \beta^\theta)M'''. \tag{4.51}$$

Figure 4.5: Optimal NRSPI Contribution in Period 2 (p_2^*) when $1 + r_2 < b$



Whenever the value of M is larger than M''', $p_2^* = M$ and $s_2^* = 0$ if the individual remains in this group. Alternatively, the individual can switch to group 1 and contribute nothing. Suppose there exists a $M'''' > M'''$ that makes the individual indifferent between the two options, then the individual will choose one of the following actions:

i. Contribute more than M and save nothing when $M < M'''$.

ii. Contribute M and save nothing when $M''' \leq M < M''''$.

iii. Not participate in NRSPI when $M \geq M''''$.

Figure 4.5 depicts the relationship between p_2^* and M when $1 + r_2 < b$, based on the discussion above. As long as $M < M'''$, p_2^* is not affected by M, and $1 + r_2 < b$ is necessary and sufficient for the individual to participate beyond the minimum contribution.

(4) Trade-Offs between s_2^* and p_2^*

It is interesting to compare the values of s_2 and p_2 at the optimum for the three groups. According to the previous section, the value of M affects the optimization. In reality, however, M is much smaller than individual income in period 2, i.e., g_2. As a result, M is smaller than both M' and M''', which means I do not need to consider corner solutions and can focus on interior solutions.

Table 4.1: Optimal Values in Period 2 (Given s_1 and g_2)

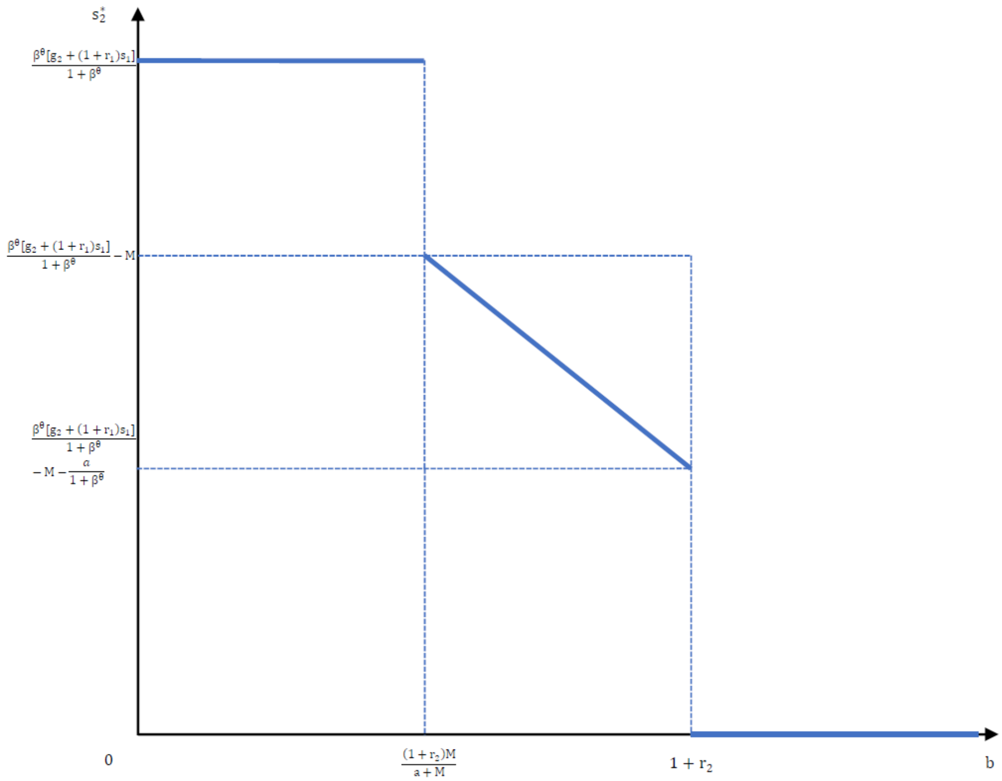
Group	Group 1	Group 2	Group 3
s_2^*	$\frac{\beta^\theta g_2+\beta^\theta(1+r_1)s_1}{1+\beta^\theta}$	$\frac{\beta^\theta(1+r_2)(g_2+(1+r_1)s_1-M)-b(a+M)}{(1+\beta^\theta)(1+r_2)}$	0
p_2^*	0	M	$\frac{\beta^\theta(g_2+(1+r_1)s_1)-a}{1+\beta^\theta}$
c_2^*	$\frac{g_2+(1+r_1)s_1}{1+\beta^\theta}$	$\frac{(1+r_2)(g_2+(1+r_1)s_1-M)+b(a+M)}{(1+\beta^\theta)(1+r_2)}$	$\frac{g_2+(1+r_1)s_1+a}{1+\beta^\theta}$

Table 4.1 summarizes the optimal values of s_2, p_2, and c_2 (assuming interior solutions) for the individuals with different participation decisions.

As I have argued, the optimal values for Group 1 are identical to those without NRSPI implementation. Comparing the optimal values for the other two groups with Group 1, I can conclude that, for the participants, NRSPI reduces savings, but enhances consumption in period 2. The increase in NRSPI contribution does not make up for the decrease in savings.

Since the only individual parameter that affects participation decisions is life expectancy, which has perfect positive correlation with b, I would like to depict how s_2^* and p_2^* change as b gradually increases in Figure 4.6 and 4.7. Based on the figures, all the optimal values stay constant within the same group except s_2^* for Group 2, ceteris paribus. From Group 1

Figure 4.6: Optimal Savings in Period 2 as Life Expectancy Increases (Interior Solutions)



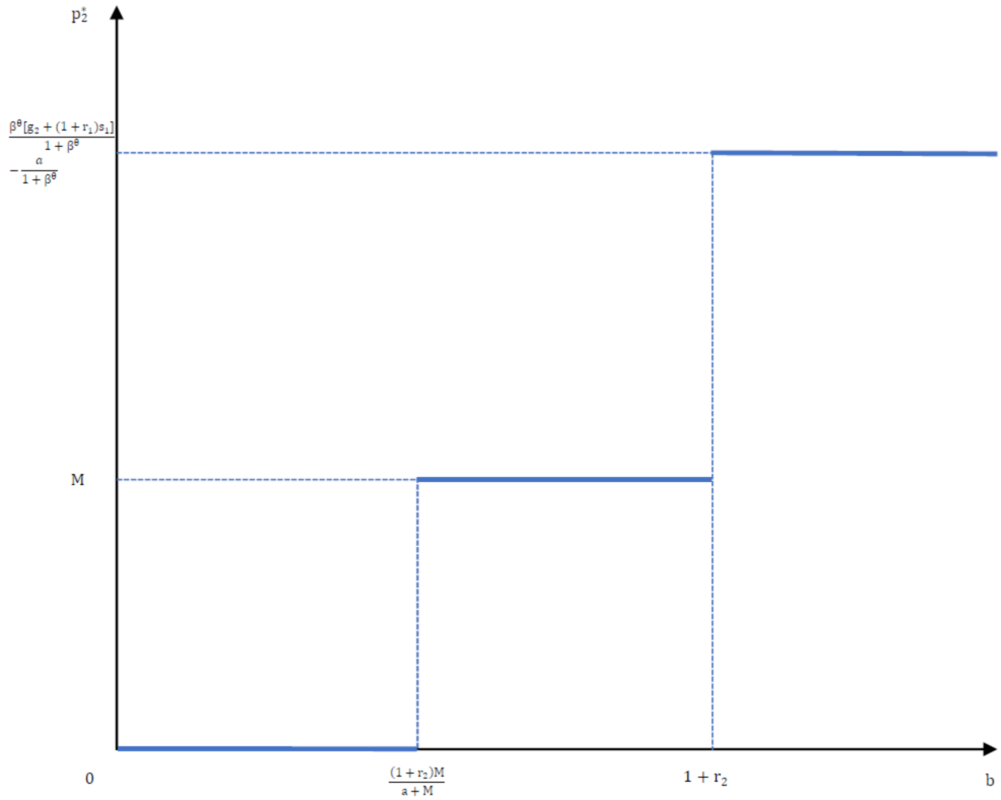
to Group 3, s_2^* becomes lower and p_2^* becomes larger, confirming that savings and NRSPI contributions are substitutes.

4.3.1.3 Period 2: Graphical Illustrations for Participation Decisions

In order to graphically illustrate how parameter changes affect individual participation decisions, I assume the current policy is characterized by a set of policy parameters $\{k, M, r_1, r_2, T\}$. The basic pension parameter can be calculated as $a = kT$. An individual has life expectancy LE, based on which the life expectancy parameter can also be calculated as $b = \frac{12(LE-60)}{T}$.

I first consider the case when $1 + r_2 > b$ and $(1 + r_2)M < b(a + M)$. We know from the derivation that the individual will participate in NRSPI at minimum contribution in this case. In Figure 4.8, I combine the intertemporal budget constraints of three participation decisions for this individual, namely, not participating (corresponding to $BC1$), participating at minimum contribution (corresponding to $BC2$), and participating beyond minimum contribution (corresponding to $BC3$). $BC1$ and $BC2$ are always parallel, while $BC3$ and

Figure 4.7: Optimal Contributions in Period 2 as Life Expectancy Increases (Interior Solutions)

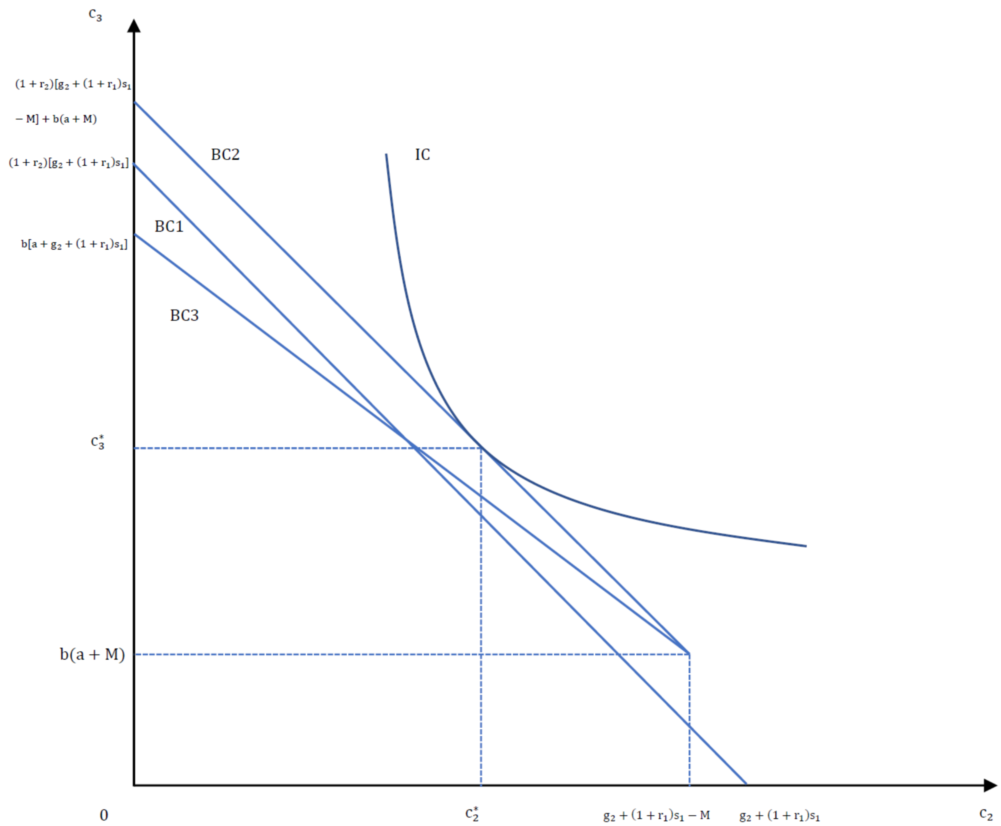


$BC2$ always intersect at a point where $c_2 = g_2 + (1 + r_1)s_1 - M$ and $c_3 = b(a + M)$. All the coordinates can be directly calculated from the conceptual model.

As we can observe, for any c_2 between 0 and $g_2+(1+r_1)s_1-M$, $BC2$ provides higher c_3, and therefore higher total expected utility than the other two budget constraints. Therefore, the individual will choose to participate at minimum contribution. When $c_2 > g_2 + (1 + r_1)s_1 - M$, however, the individual can only choose to not participate in NRSPI since she will never be eligible for it.

Following Figure 4.8, I am able to explain the reason for corner solutions to occur in Figure 4.9. This is an example where there is no point of tangency between $BC2$ and the indifference curve for $c_2 \in [0, g_2 + (1 + r_1)s_1 - M]$ because M is considerably large. The highest utility that can be achieved by participating at minimum contribution is represented by $IC2$, which is lower than the utility represented by $IC1$. Therefore, the individual will

Figure 4.8: Intertemporal Budget Constraints with Different Participation Decisions for a Given Individual with $1 + r_2 > b$ and $(1 + r_2)M < b(a + M)$



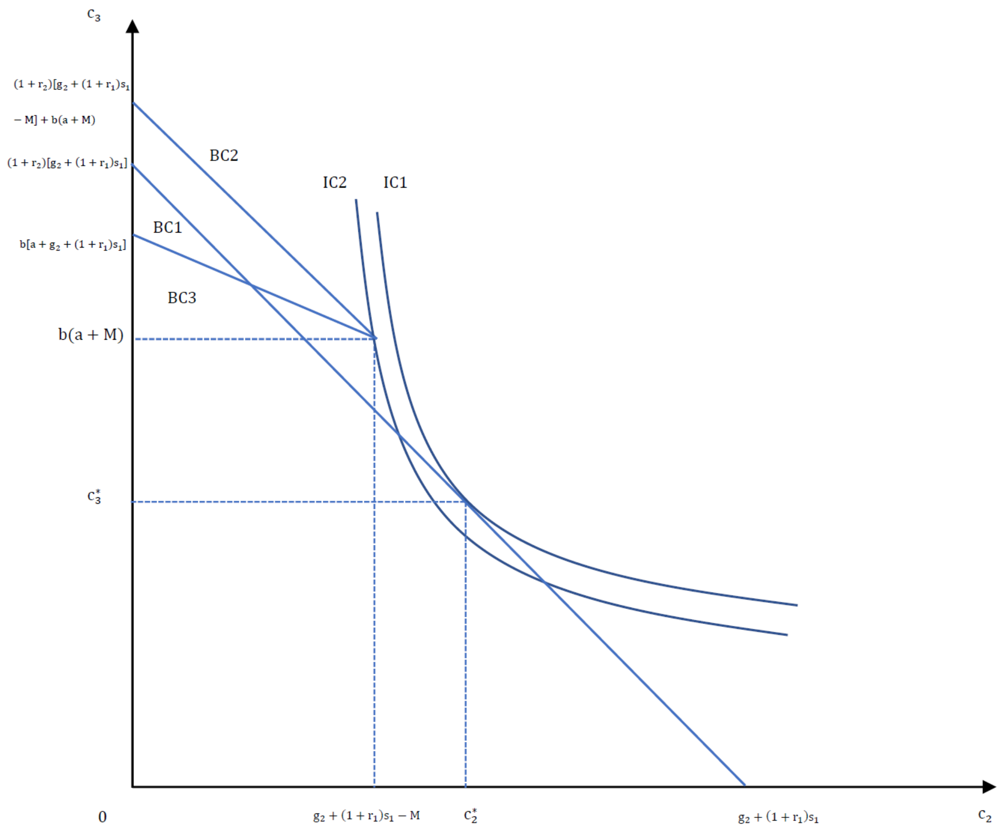
not participate in NRSPI even if $(1 + r_2)M < b(a + M)$.

I next illustrate the effects of changing M on participation decisions. When M increases to M^I, $b(a + M) - (1 + r_2)M$ will decrease, meaning that $BC2$ will translate downwards to $BC2^I$. If $BC2^I$ is still above $BC1$, the individual will not change her decision as long as there is an interior solution as I have described. If $BC2^I$ translates below $BC1$, which is shown in Figure 4.10, the individual will switch to not participating and consume at c_2^{*I} and c_3^{*I}. The expected utility, represented by IC^I, will decrease.

When M decreases to M^D, $b(a + M) - (1 + r_2)M$ will increase, indicating that $BC2$ will translate upwards to $BC2^D$, which is higher than $BC1$ and $BC3$. As is shown in Figure 4.11, the individual will continue to participate at minimum contribution, and the expected utility will increase.

I then discuss the effects of changing monthly basic pension payment k. When k increases

Figure 4.9: An Example of Corner Solution Where the Individual Does Not Participate in NRSPI with $1 + r_2 > b$ and $(1 + r_2)M < b(a + M)$

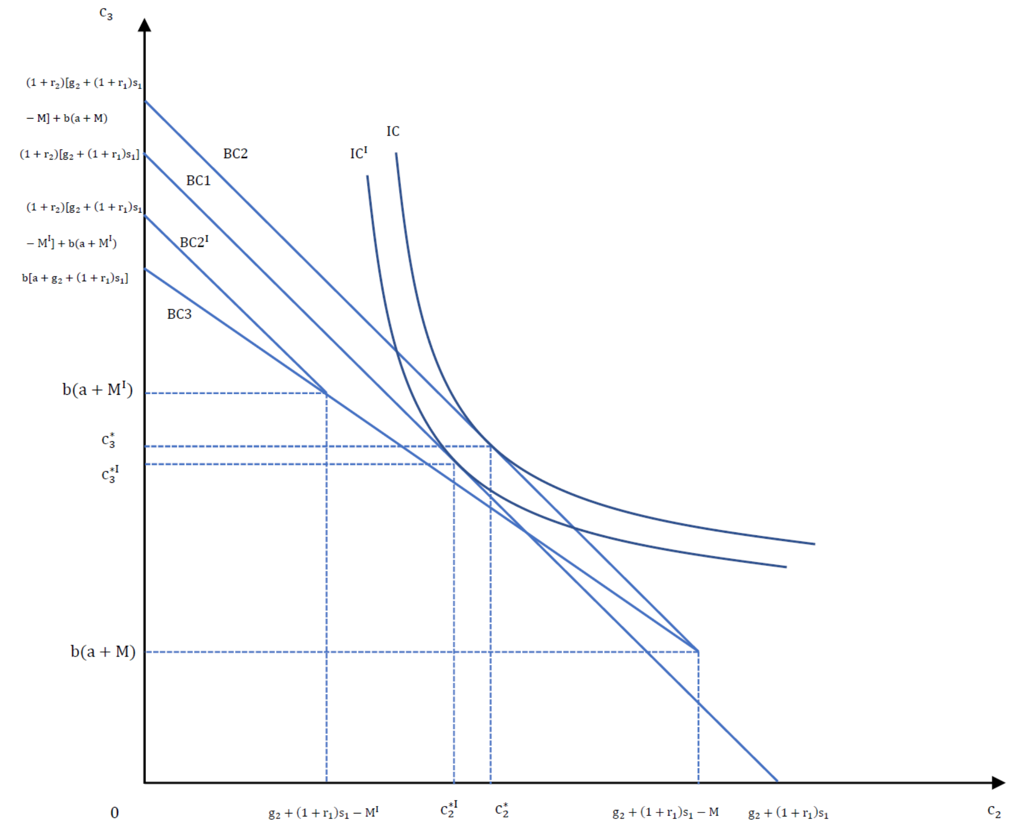


to k^I, a increases to a^I, correspondingly. As is shown in Figure 4.12, $BC2$ and $BC3$ will both translate upwards to $BC2^I$ and $BC3^I$, and $BC2^I$ remains to be on top of the other two. Thus, the individual will keep participating at minimum contribution, and the expected utility will increase (indifference curve translates from IC to IC^I).

When k decreases to k^D, a decreases to a^D, correspondingly. Then, as is depicted in Figure 4.13, $BC2$ and $BC3$ will both translate downwards to $BC2^D$ and $BC3^D$. If $BC2^D$ is still above $BC1$, the participation decision will not change. Otherwise, the individual will switch to not participating and consume c_2^{*D} and c_3^{*D}. The expected utility, represented by IC^D, will decrease.

It is worth noting that r_1 does not affect participation decisions at all, and I can focus on r_2. When r_2 increases to r_2^I, $(1+r_2)(g_2+(1+r_1)s_1)$ and $(1+r_2)(g_2+(1+r_1)s_1-M)+b(a+M)$ will increase, and the increase in the former is larger than the latter. Hence, $BC1$ and $BC2$

Figure 4.10: The Effects of Increasing M on Participation Decisions

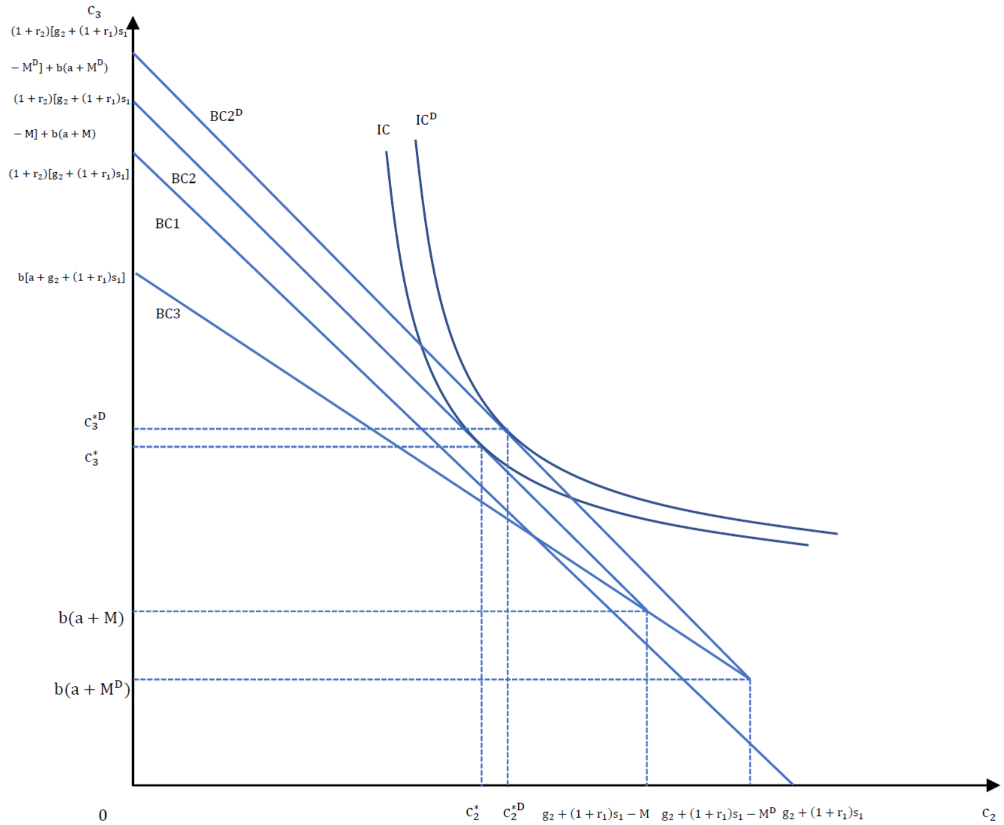


will both translate upwards and rotate clockwise to $BC1^I$ and $BC2^I$. If $BC2^I$ is still steeper than $BC1^I$, no participation change will be made. However, once $BC1^I$ is steeper than $BC2^I$, the individual will choose to not participate in NRSPI and the expected utility will increase, which are illustrated in Figure 4.14.

When r_2 decreases to r_2^D, $(1+r_2)(g_2+(1+r_1)s_1)$ and $(1+r_2)(g_2+(1+r_1)s_1-M)+b(a+M)$ will decrease, and the decrease in the former is larger than the latter. Therefore, $BC1$ and $BC2$ will both translate downwards and rotate counter-clockwise to $BC1^D$ and $BC2^D$, with $BC2^D$ being steeper than $BC1^D$. If $BC2^D$ is still steeper than $BC3$, the individual sticks to the same decision. Once $BC2^D$ is flatter than $BC3$, as is presented in Figure 4.15, the individual will instead choose to contribute more than the minimum and save nothing. The expected utility will decrease, which can be obtained by comparing IC^D and IC.

As for the effects of T, I have shown that when T increases to T^I, a will increase but

Figure 4.11: The Effects of Decreasing M on Participation Decisions

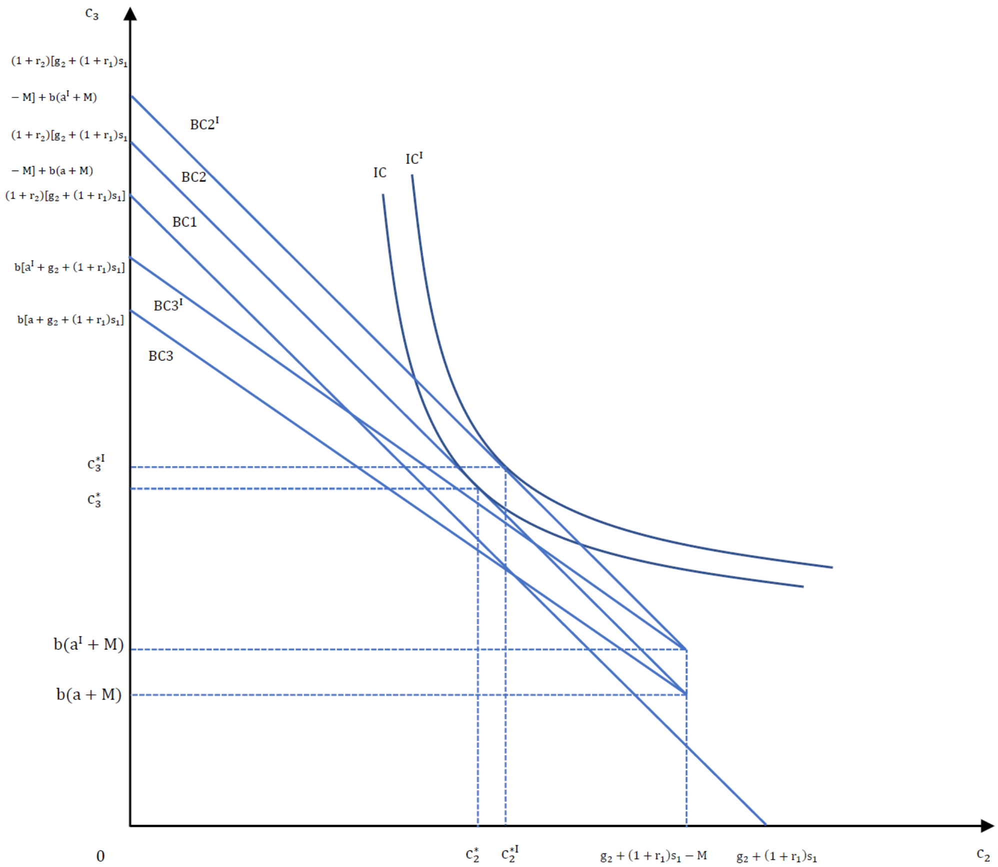


b as well as $b(a+M)$ will decrease. As a consequence, $BC2$ will translate downwards to $BC2^I$, and $BC3$ will translate downwards and rotate counter-clockwise to $BC3^I$, suggesting that $BC2^I$ is always steeper than $BC3^I$. If $BC2^I$ is still above $BC1$, the individual will not change participation decision. Otherwise, she will no longer participate in NRSPI, and corresponding expected utility will be reduced, as is shown in Figure 4.16.

When T decreases to T^D, a will decrease but b as well as $b(a+M)$ will increase. Consequently, $BC2$ will translate upwards to $BC2^D$, and $BC3$ will translate upwards and rotate clockwise to $BC3^D$. As long as $BC2^D$ is still steeper than $BC3^D$, the individual goes on to participate at minimum contribution. If $BC2^D$ becomes flatter than $BC3^D$, as is described in Figure 4.17, the individual will prefer participating beyond minimum contribution, and her expected utility will also increase.

Besides the policy parameters, I am also interested in how the individual changes par-

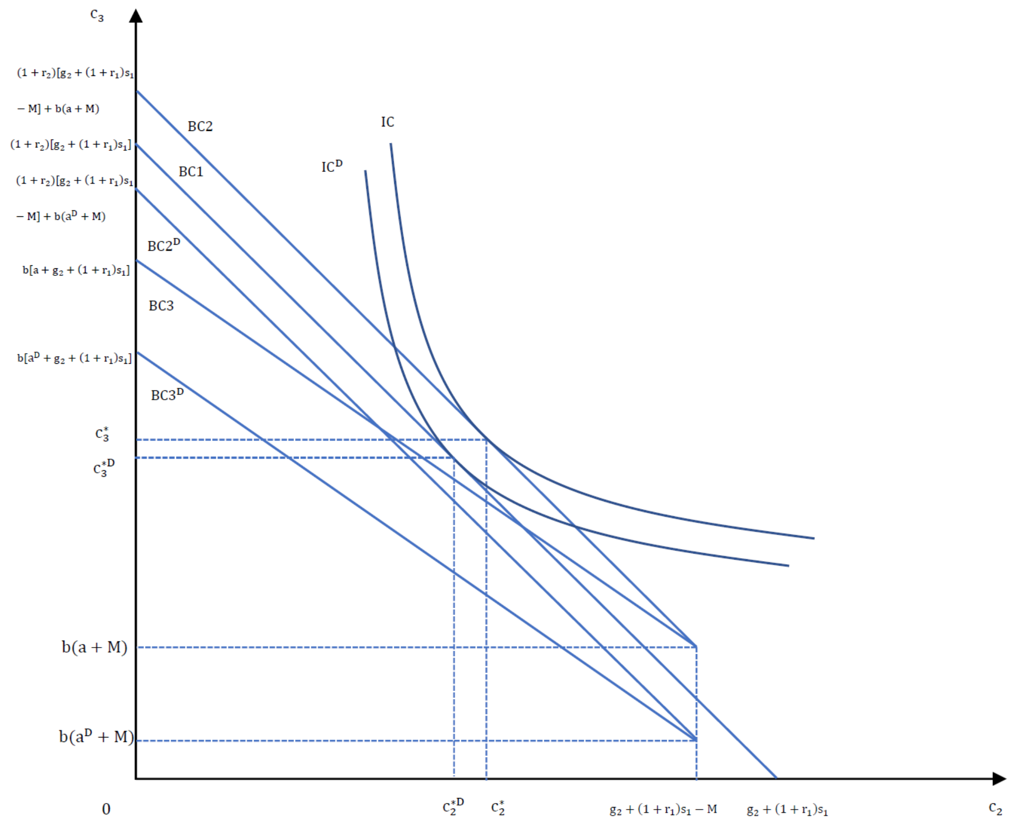
Figure 4.12: The Effects of Increasing k on Participation Decisions



ticipation decisions based on life expectancy. Figure 4.18, qualitatively identical to Figure 4.17, reflects the key idea about it. When life expectancy increases, b and $b(a+M)$ will also increase. Then $BC2$ will translate upwards to $BC2^I$, and $BC3$ will translate upwards and rotate clockwise to $BC3^I$. Once the increase is large enough to make $BC3^I$ steeper than $BC2^I$, i.e., $b > 1 + r_2$, the individual will contribute more than the minimum and enjoy higher expected utility.

When life expectancy decreases, b and $b(a+M)$ will also decrease. Hence, $BC2$ will translate downwards to $BC2^D$, and $BC3$ will translate downwards and rotate counter-clockwise to $BC3^D$. If the translation of $BC2$ is sufficient to place $BC2^D$ below $BC1$, the individual will not participate in NRSPI anymore, and her expected utility will also decrease. This is reflected in Figure 4.19.

Figure 4.13: The Effects of Decreasing k on Participation Decisions

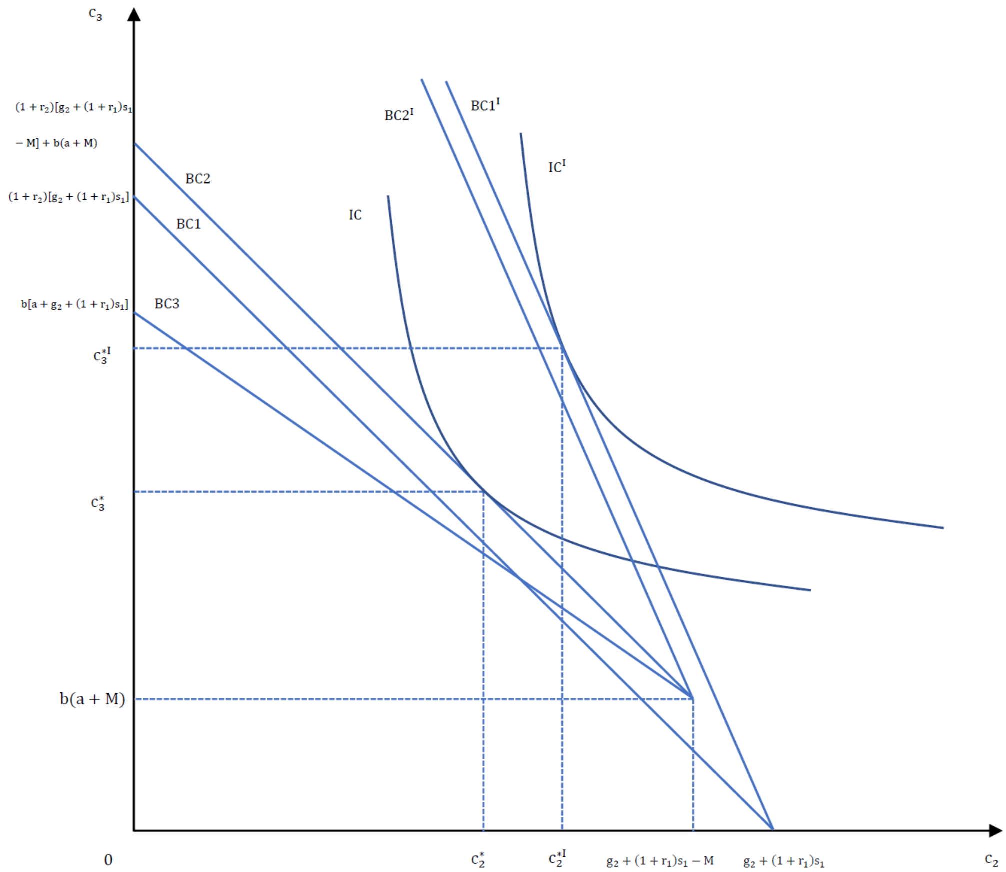


4.3.1.4 Period 1: Optimization

Finally I look at period 1. I first derive optimization mathematically, and then discuss comparative statics in this period. Similar with period 2, I also need to separately discuss different groups of individuals based on heterogeneous life expectancies. The individuals who live in all the three periods (thus, $LE \geq 60$) are already defined as Group 1, Group 2, and Group 3, respectively in Section 4.3.1.2. I further define the individuals who live in period 1 and 2 (thus, $45 \leq LE < 60$) as Group 4, and individuals who only live in period 1 (thus, $16 \leq LE < 45$) as Group 5. It is reasonable for me to prioritize the discussion of the first three groups because they have the most complicated optimization problem, which I am more interested in.

By plugging in the binding budget constraint (4.19) and eliminating c_1, I obtain the

Figure 4.14: The Effects of Increasing r_2 on Participation Decisions



optimization problem in period 1 (applied to Group 1-4):

$$\max_{s_1} \ ln(I_1 - s_1) + \beta E_1[W_2(s_1, g_2)]. \tag{4.52}$$

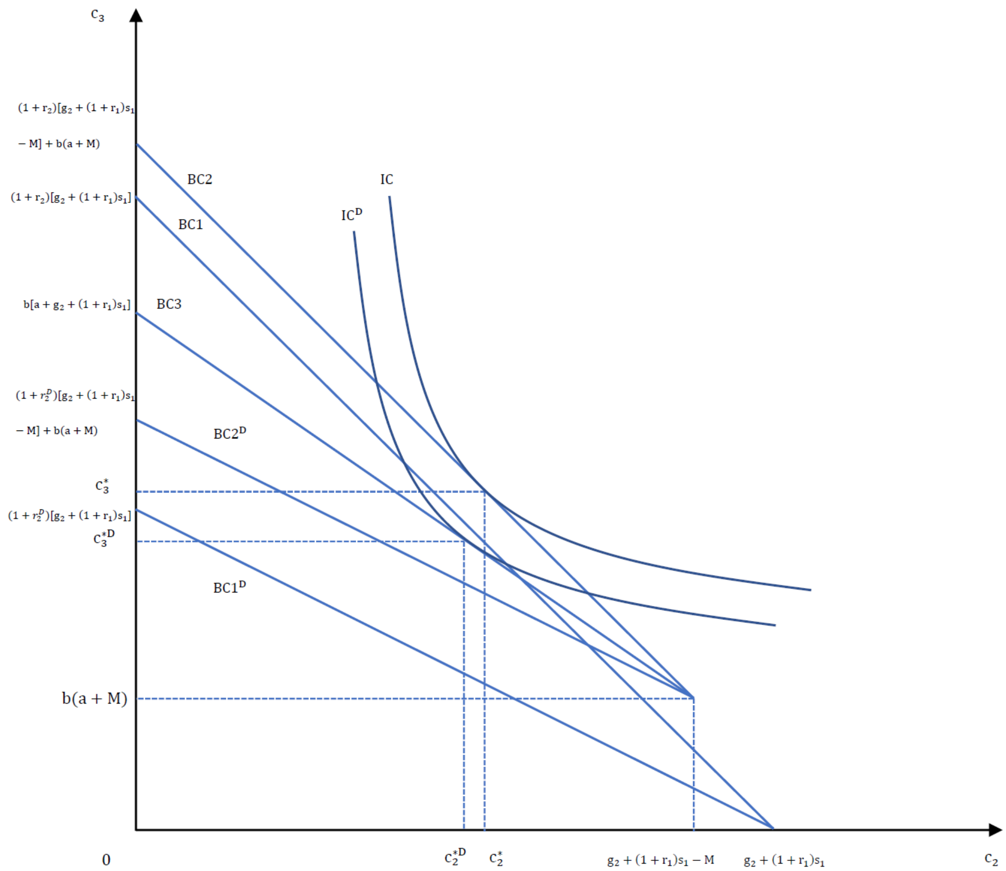
The first-order condition w.r.t. s_1 is:

$$\beta E_1[\frac{\partial W_2(s_1, g_2)}{\partial s_1}] \leq \frac{1}{I_1 - s_1}. \tag{4.53}$$

In addition, according to my assumption about g_2, we know:

$$W_2(s_1, g_2) = \begin{cases} W_2(s_1, \mu_2), & probability = 1 - \epsilon; \\ W_2(s_1, \mu_2 - \sigma_2), & probability = \epsilon. \end{cases} \tag{4.54}$$

Figure 4.15: The Effects of Decreasing r_2 on Participation Decisions



Therefore, expected $W_2(s_1, g_2)$ in period 1 is:

$$E_1[W_2(s_1, g_2)] = (1 - \epsilon)W_2(s_1, \mu_2) + \epsilon W_2(s_1, \mu_2 - \sigma_2). \tag{4.55}$$

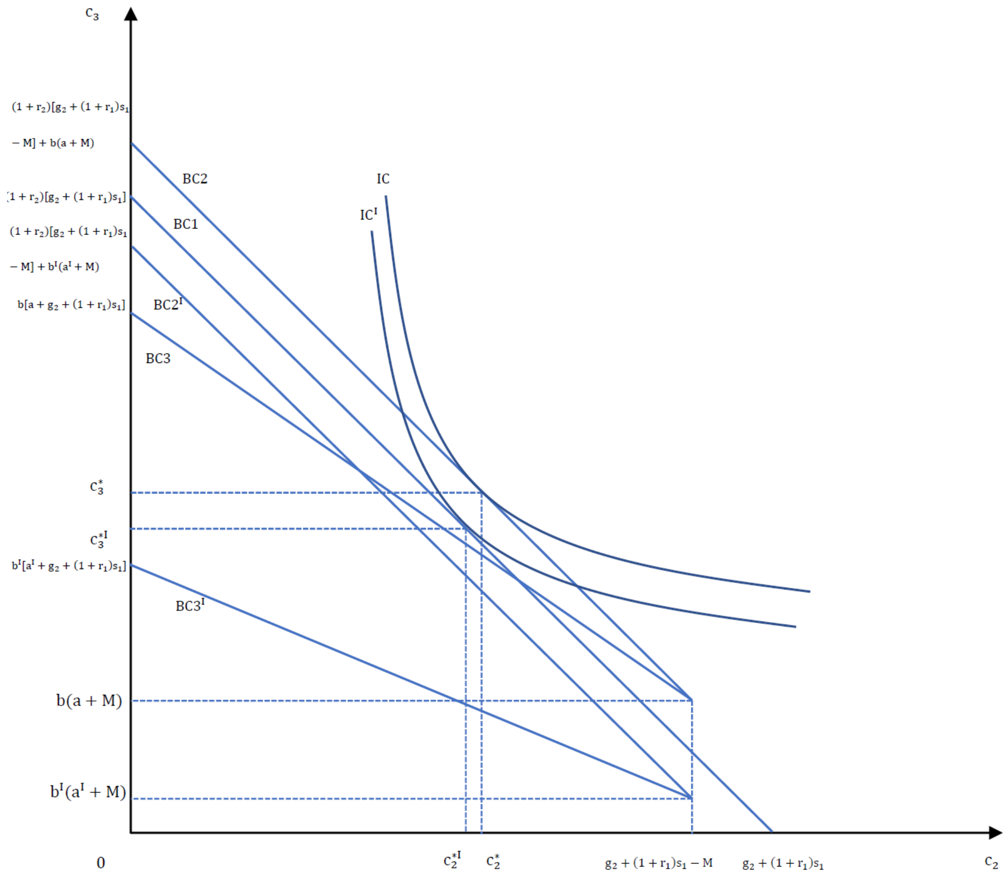
(1) Group 1: $1 + r_2 \geq b$ **and** $(1 + r_2)M \geq b(a + M)$

The individuals in Group 1 will not participate in NRSPI. The binding FOC (4.53), combined with equations (4.32) and (4.55), leads to the equation:

$$\begin{aligned} \frac{1}{I_1 - s_1} &= \beta\left[\frac{(1-\epsilon)(1+\beta^\theta)(1+r_1)}{\mu_2 + (1+r_1)s_1} + \frac{\epsilon(1+\beta^\theta)(1+r_1)}{\mu_2 - \sigma_2 + (1+r_1)s_1}\right] \\ &= \frac{\beta(1+\beta^\theta)(1+r_1)[(1+r_1)s_1 + \mu_2 - (1-\epsilon)\sigma_2]}{[(1+r_1)s_1 + \mu_2][(1+r_1)s_1 + \mu_2 - \sigma_2]}. \end{aligned} \tag{4.56}$$

Denoting $A_1 = [\beta(1+\beta^\theta)+1](1+r_1)^2$, $B_1 = [\beta(1+\beta^\theta)+2](1+r_1)\mu_2 - \beta(1+\beta^\theta)(1+r_1)^2 I_1 -$

Figure 4.16: The Effects of Increasing T on Participation Decisions

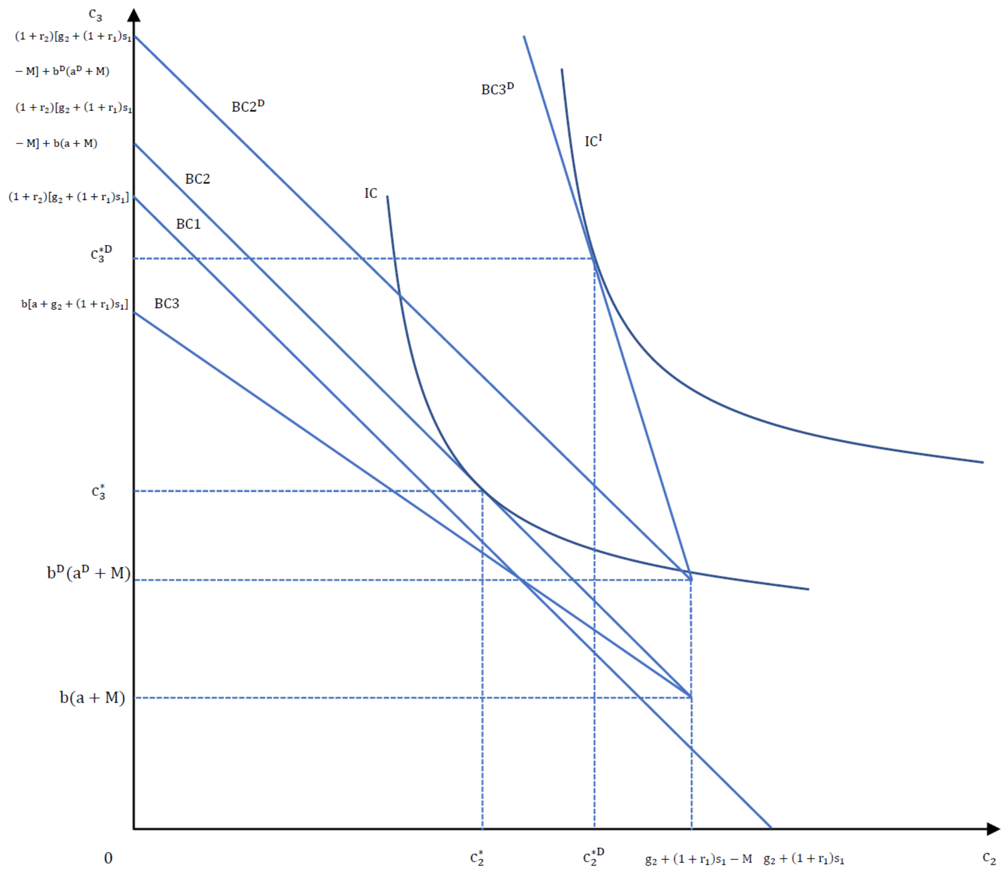


$[(1-\epsilon)\beta(1+\beta^\theta)+1](1+r_1)\sigma_2$, and $C_1 = \mu_2(\mu_2-\sigma_2) - \beta(1+\beta^\theta)(1+r_1)[\mu_2-(1-\epsilon)\sigma_2]I_1$, I can calculate $\Delta_1 = B_1^2 - 4A_1C_1 = (1+r_1)^2\{[\beta(1+\beta^\theta)(\mu_2+(1+r_1)I_1) - ((1-\epsilon)\beta(1+\beta^\theta)+1)\sigma_2]^2 + 4\epsilon\sigma_2\beta(1+\beta^\theta)(\mu_2+(1+r_1)I_1)\} > 0$.

In theory, we have two roots, and therefore two solutions for s_1^*. However, I will demonstrate that, one root is always negative. If $B_1 \geq 0$, it is straightforward that $-B_1 - \sqrt{\Delta_1} < 0$. If $B_1 < 0$, it follows that $\beta(1+\beta^\theta)(\mu_2+(1+r_1)I_1) - ((1-\epsilon)\beta(1+\beta^\theta)+1)\sigma_2 < -2(\mu_2 - \beta(1+\beta^\theta)(1+r_1)I_1) < \frac{-2}{\mu_2-\sigma_2}C_1$.[9] Suppose $C_1 < 0$, then $\Delta_1 = B_1^2 - 4A_1C_1 < B_1^2$, which means $-B_1 - \sqrt{\Delta_1} < -B_1 - (-B_1) = 0$. Suppose $C_1 \geq 0$, then $\beta(1+\beta^\theta)(\mu_2 + (1+r_1)I_1) - ((1-\epsilon)\beta(1+\beta^\theta)+1)\sigma_2 < 0$.[10] It turns out that $-B_1 - \sqrt{\Delta_1} < -B_1 - \sqrt{(1+r_1)^2[\beta(1+\beta^\theta)(\mu_2+(1+r_1)I_1) - ((1-\epsilon)\beta(1+\beta^\theta)+1)\sigma_2]^2} = -B_1 + (1+r_1)[\beta(1+$

[9]Note that $1-\epsilon < 1$.
[10]Note that $\mu_2 > \sigma_2$.

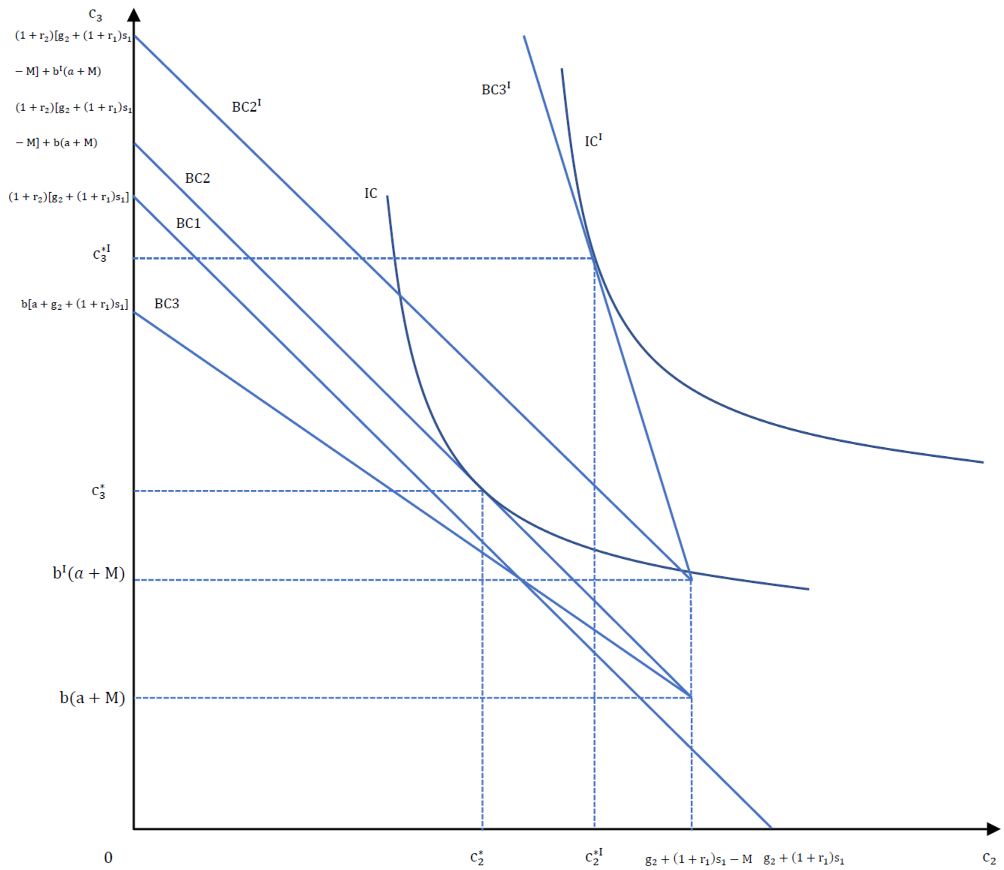
Figure 4.17: The Effects of Decreasing T on Participation Decisions



$\beta^{\theta})(\mu_2 + (1 + r_1)I_1) - ((1 - \epsilon)\beta(1 + \beta^{\theta}) + 1)\sigma_2] = -2(1 + r_1)(\mu_2 - \beta(1 + \beta^{\theta})(1 + r_1)I_1) < 0.$ Therefore, it is always true that $-B_1 - \sqrt{\Delta_1} < 0$.

Keeping in mind that s_1^* cannot be negative, we have at most one interior solution for s_1^* (i.e., $s_1^* > 0$). The corner solution, i.e., $s_1^* = 0$, incurs when $-B_1 + \sqrt{\Delta_1} < 0$, or $\sqrt{\Delta_1} < B_1$, which implies that $C_1 > 0$. Based on the equation for C_1, we know that C_1 is positively related with μ_2, but negatively related with β, I_1, σ_2, and r_1. Hence, there is more likely to be a corner solution if: (1) the individual care less about the future; (2) the individual has less cash on hand in period 1; (3) the individual expects to earn more and encounter less income shock in period 2; and (4) the normalized interest rate in period 1 is lower. Hereafter, I would like to focus on interior solutions since I can do further comparative static analyses on them.

Figure 4.18: The Effects of Increasing Life Expectancy on Participation Decisions



The interior solution for s_1 is:

$$s_1^* = \frac{-B_1 + \sqrt{\Delta_1}}{2A_1}. \tag{4.57}$$

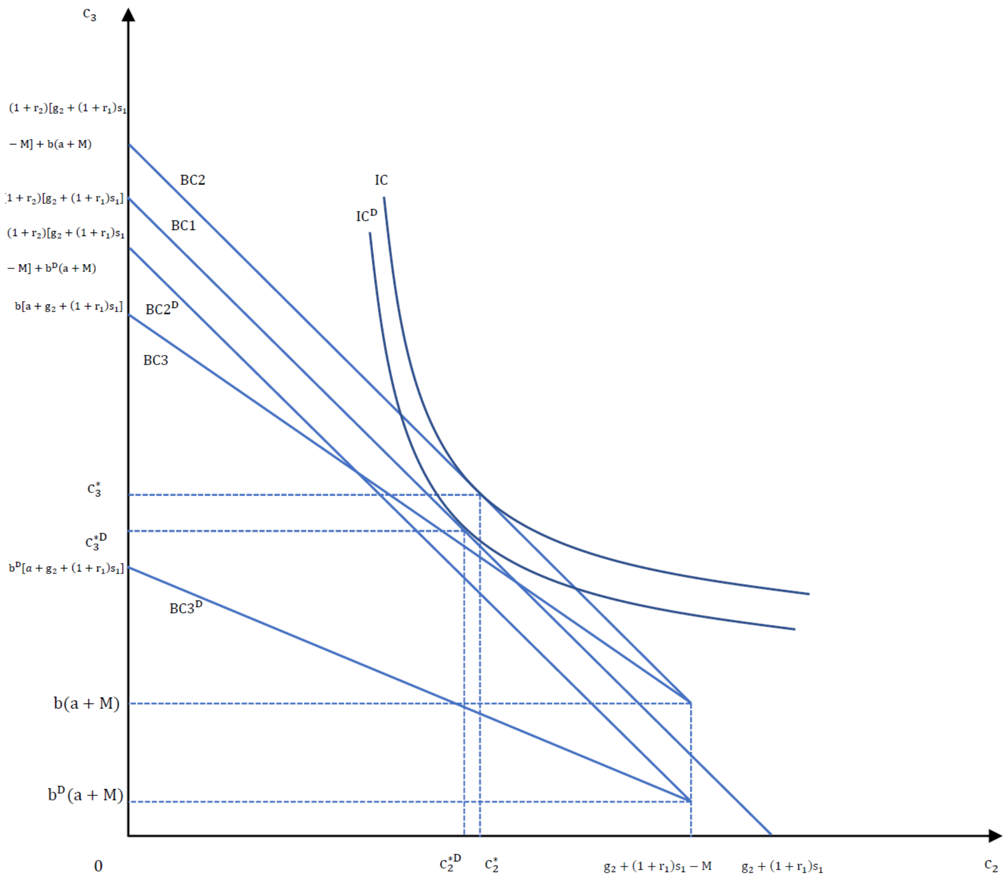
And optimal consumption c_1 is:

$$c_1^* = I_1 - s_1^* = I_1 + \frac{B_1 - \sqrt{\Delta_1}}{2A_1}. \tag{4.58}$$

(2) Group 2: $1 + r_2 \geq b$ **and** $(1 + r_2)M < b(a + M)$

In this group, the individuals will participate in NRSPI at the minimum contribution, i.e., $p_2 = M$. The binding FOC (4.53), combined with equations (4.43) and (4.55), leads to

Figure 4.19: The Effects of Decreasing Life Expectancy on Participation Decisions



the following equation:

$$
\begin{aligned}
\frac{1}{I_1 - s_1} =& \beta[\frac{(1-\epsilon)(1+\beta^\theta)(1+r_1)(1+r_2)}{(1+r_2)(\mu_2+(1+r_1)s_1)+ab+(b-1-r_2)M} \\
&+ \frac{\epsilon(1+\beta^\theta)(1+r_1)(1+r_2)}{(1+r_2)(\mu_2-\sigma_2+(1+r_1)s_1)+ab+(b-1-r_2)M}] \\
&= \frac{\beta(1+\beta^\theta)(1+r_1)[(1+r_1)s_1+X-(1-\epsilon)\sigma_2]}{[(1+r_1)s_1+X][(1+r_1)s_1+X-\sigma_2]},
\end{aligned}
\tag{4.59}
$$

where the parameter $X = \frac{b(a+M)-(1+r_2)M}{1+r_2} + \mu_2 > \mu_2 > 0$. Now I am able to denote $A_2 = [\beta(1+\beta^\theta)+1](1+r_1)^2$, $B_2 = [\beta(1+\beta^\theta)+2](1+r_1)X - \beta(1+\beta^\theta)(1+r_1)^2 I_1 - [(1-\epsilon)\beta(1+\beta^\theta)+1](1+r_1)\sigma_2$, and $C_2 = X(X-\sigma_2) - \beta(1+\beta^\theta)(1+r_1)[X-(1-\epsilon)\sigma_2]I_1$. Then I can calculate $\Delta_2 = B_2^2 - 4A_2C_2 = (1+r_1)^2\{[\beta(1+\beta^\theta)(X+(1+r_1)I_1) - ((1-\epsilon)\beta(1+\beta^\theta)+1)\sigma_2]^2 + 4\epsilon\sigma_2\beta(1+\beta^\theta)(X+(1+r_1)I_1)\} > 0$.

Following the same logic as the previous group, I can prove that $-B_2 - \sqrt{\Delta_2} < 0$. Similar with Group 1, I cannot rule out the possibility for a corner solution, i.e., $s_1^* = 0$ (and therefore $c_1^* = I_1$). On the other hand, the interior solution for s_1 is:

$$s_1^* = \frac{-B_2 + \sqrt{\Delta_2}}{2A_2}. \tag{4.60}$$

And optimal consumption c_1 is:

$$c_1^* = I_1 - s_1^* = I_1 + \frac{B_2 - \sqrt{\Delta_2}}{2A_2}. \tag{4.61}$$

(3) Group 3: $1 + r_2 < b$

Individuals in this group will participate in NRSPI and contribute more than the minimum, i.e., $p_2 > M$. The binding FOC (4.53), combined with equations (4.48) and (4.55), leads to the equation:

$$\begin{aligned}\frac{1}{I_1 - s_1} &= \beta[\frac{(1-\epsilon)(1+\beta^\theta)(1+r_1)}{\mu_2 + (1+r_1)s_1 + a} + \frac{\epsilon(1+\beta^\theta)(1+r_1)}{\mu_2 - \sigma_2 + (1+r_1)s_1 + a}] \\ &= \frac{\beta(1+\beta^\theta)(1+r_1)[(1+r_1)s_1 + Y - (1-\epsilon)\sigma_2]}{[(1+r_1)s_1 + Y][(1+r_1)s_1 + Y - \sigma_2]},\end{aligned} \tag{4.62}$$

where the parameter $Y = a + \mu_2 \geq X > \mu_2 > 0$. Now I am able to denote $A_3 = [\beta(1+\beta^\theta) + 1](1+r_1)^2$, $B_3 = [\beta(1+\beta^\theta)+2](1+r_1)Y - \beta(1+\beta^\theta)(1+r_1)^2 I_1 - [(1-\epsilon)\beta(1+\beta^\theta)+1](1+r_1)\sigma_2$, and $C_3 = Y(Y-\sigma_2) - \beta(1+\beta^\theta)(1+r_1)[Y-(1-\epsilon)\sigma_2]I_1$. Then I can calculate $\Delta_3 = B_3^2 - 4A_3C_3 = (1+r_1)^2\{[\beta(1+\beta^\theta)(Y+(1+r_1)I_1) - ((1-\epsilon)\beta(1+\beta^\theta)+1)\sigma_2]^2 + 4\epsilon\sigma_2\beta(1+\beta^\theta)(Y+(1+r_1)I_1)\} > 0$.

I can, again, demonstrate that $-B_3 - \sqrt{\Delta_3} < 0$. Apart from the corner solution $s_1^* = 0$ when $-B_3 + \sqrt{\Delta_3} < 0$, the interior solution for s_1 is:

$$s_1^* = \frac{-B_3 + \sqrt{\Delta_3}}{2A_3}. \tag{4.63}$$

And optimal consumption c_1 is:

$$c_1^* = I_1 - s_1^* = I_1 + \frac{B_3 - \sqrt{\Delta_3}}{2A_3}. \tag{4.64}$$

I summarize the components of optimal solutions in this three groups, i.e., A_i, B_i, C_i $(i = 1, 2, 3)$ in Table 4.2.[11] Given the same parameters, we have $\frac{-B_1+\sqrt{\Delta_1}}{2A_1} > \frac{-B_2+\sqrt{\Delta_2}}{2A_2}$ and $\frac{-B_1+\sqrt{\Delta_1}}{2A_1} > \frac{-B_3+\sqrt{\Delta_3}}{2A_3}$. Thus, the implementation of NRSPI will enhance the consumption and reduce the savings of participants in the pre-contribution period (period 1).

Table 4.2: Components of Optimal Values in Period 1

Group 1: Not participating	
A_1	$[\beta(1+\beta^\theta)+1](1+r_1)^2$
B_1	$[\beta(1+\beta^\theta)+2](1+r_1)\mu_2 - \beta(1+\beta^\theta)(1+r_1)^2 I_1 - [(1-\epsilon)\beta(1+\beta^\theta)+1](1+r_1)\sigma_2$
C_1	$\mu_2(\mu_2-\sigma_2) - \beta(1+\beta^\theta)(1+r_1)[\mu_2-(1-\epsilon)\sigma_2]I_1$
Group 2: Participating at the Minimum Contribution	
A_2	$[\beta(1+\beta^\theta)+1](1+r_1)^2$
B_2	$[\beta(1+\beta^\theta)+2](1+r_1)X - \beta(1+\beta^\theta)(1+r_1)^2 I_1 - [(1-\epsilon)\beta(1+\beta^\theta)+1](1+r_1)\sigma_2$
C_2	$X(X-\sigma_2) - \beta(1+\beta^\theta)(1+r_1)[X-(1-\epsilon)\sigma_2]I_1$
Group 3: Participating beyond the Minimum Contribution	
A_3	$[\beta(1+\beta^\theta)+1](1+r_1)^2$
B_3	$[\beta(1+\beta^\theta)+2](1+r_1)Y - \beta(1+\beta^\theta)(1+r_1)^2 I_1 - [(1-\epsilon)\beta(1+\beta^\theta)+1](1+r_1)\sigma_2$
C_3	$Y(Y-\sigma_2) - \beta(1+\beta^\theta)(1+r_1)[Y-(1-\epsilon)\sigma_2]I_1$

(4) Group 4: $45 \leq LE < 60$

The individuals in Group 4 live in period 1 and 2, i.e., have life expectancy between 45 and 60. In fact, this group of individuals can be regarded as a special subgroup of Group 1, whose b and β^θ parameters both equal 0. Optimal savings and consumption are similar with equations (4.57) and (4.58). Henceforth, I no longer discuss Group 4 specially.

(5) Group 5: $16 \leq LE < 45$

The individuals in Group 5 only live in period 1, i.e., has life expectancy less than 45. A representative individual of this group will consume all cash on hand in period 1 and make no savings or NRSPI contribution. Actually, Group 5 can even be considered as the special

[11] As I have discussed, $X = \frac{b(a+M)-(1+r_2)M}{1+r_2} + \mu_2$ and $Y = a + \mu_2$.

subgroup for Group 4, who always have corner solutions $s_1^* = 0$ since $\beta = 0$ for all of them. No actual optimization is involved for this group of individuals, and I am not very interested in this group.

Comparing the optimal savings and consumption in period 1 and 2, I can draw an important conclusion that, for the participants, the implementation of NRSPI enhances consumption in both period 1 and period 2. In period 1, participants consume more since they expect a secure source of income in old age, and do not need to save as much for the future. In period 2, although participants have the additional financial responsibility to contribute to NRSPI, they still manage to consume more by further reducing savings. In other words, NRSPI contribution crowds out savings with a ratio larger than 1. Even with the same level of income, NRSPI participants have more to spend before receiving the benefits. Therefore, NRSPI has a potentially significant effect on alleviating poverty, which provides a conceptual support for the empirical work of Zhang, Giles, and Zhao (2014), Zheng and Wang (2020), and Chi (2022). From this perspective, NRSPI interacts with the Dibao program, which is a major anti-poverty social assistance program in rural China as I have described in the previous section. The existence of NRSPI reinforces the effects of Dibao in terms of getting rural residents out of poverty.

4.3.1.5 Comparative Statics: Parameters of Interest

Section 4.3.1.3 graphically shows how parameter changes influence individual participation decisions specifically for individuals in Group 2. The comparative statics for the individuals not changing participation decisions (i.e., within the same group before and after parameter changes), as well as the overall changes in the proportions of three groups, are not yet discussed. Noting that optimal values in period 2 are related with those in period 1, I discuss comparative statics in period 1 before period 2.

For the individuals with expectancy higher than 60, the optimal values of savings and consumption in period 1 and period 2 are determined by a set of parameters, which can be categorized into two parameter groups:[12]

i. Individual parameters: β (discount parameter), I_1 (cash on hand in period 1), μ_2 (expected disposable income in period 2), σ_2 (income shock in period 2), and LE (life expectancy at age 16);

ii. Policy parameters: k (monthly basic pension payment), M (minimum total contribution for eligibility), T (policy-specified life span after 60), and r_1 and r_2 (long-term normalized interest rates for savings).

According to this categorization and my derivations of the theoretical model, except life expectancy, all the individual parameters do not influence the individual's participation decision. On the opposite, every policy parameter plays a role in the participation decision-making process. We need to be aware of the differences between these groups of parameters. Simply put, individual parameters characterize heterogeneous individuals, and changes in policy parameters are applied to all individuals with different individual parameters. In particular, I assume market savings rates are given, and normalized savings rates are negatively related with NRSPI interest rates.

4.3.1.6 Comparative Statics in Period 1: Individual Parameters

Since we have two categories of parameters that own distinctive characteristics, I first analyze how different individual parameters affect optimal savings and consumption in period 1. Then I will focus on policy parameters, evaluating the potential impacts brought by different policy specifications.

Based on the optimal values in period 1, individual parameters that affect optimal savings and consumption are the discount parameter, life expectancy at age 16, initial cash on hand, income, and income shock.

(1) Discount Parameter

Let us first consider the discount parameter, i.e., β. It is not meaningful to discuss the effects of β and β^θ separately since they always appear together in the form of $\beta(1+\beta^\theta)$,

[12]Note that I am interested in the "original" parameters, rather than the parameters defined in the model for convenience, such as a and b.

so I define a new parameter γ which equals $\gamma = \beta(1+\beta^{\theta})$ to simplify the derivations. It naturally follows that γ is increasing in β. Taking partial derivatives of s_1^* and c_1^* w.r.t. γ, I obtain the following results:

$$
\begin{aligned}
\frac{\partial s_{1,i}^*}{\partial \gamma} =& -\frac{1}{1+\gamma}s_{1,i}^* + \frac{1}{\gamma}\{s_{1,i}^* + \frac{1}{2A_i}[\frac{(1+r_1)^2}{\sqrt{\Delta_i}}(\gamma(D_i+(1+r_1)I_1) - ((1-\epsilon)\gamma+1)\sigma_2 \\
&- 2\epsilon\gamma(D_i+(1+r_1)I_1))\sigma_2 + 2(1+r_1)D_i - (1+r_1)\sigma_2]\} \\
=&(\frac{1}{\gamma} - \frac{1}{1+\gamma})s_{1,i}^* + \frac{1}{2\gamma A_i}[\frac{(1+r_1)^2}{\sqrt{\Delta_i}}((1-2\epsilon)\gamma(D_i+(1+r_1)I_1) - ((1-\epsilon)\gamma+1)\sigma_2)\sigma_2 \\
&+ 2(1+r_1)D_i - (1+r_1)\sigma_2],
\end{aligned}
\tag{4.65}
$$

$$
\begin{aligned}
\frac{\partial c_{1,i}^*}{\partial \gamma} =& -\frac{\partial s_{1,i}^*}{\partial \gamma} \\
=& -(\frac{1}{\gamma} - \frac{1}{1+\gamma})s_{1,i}^* - \frac{1}{2\gamma A_i}[\frac{(1+r_1)^2}{\sqrt{\Delta_i}}((1-2\epsilon)\gamma(D_i+(1+r_1)I_1) - ((1-\epsilon)\gamma+1)\sigma_2)\sigma_2 \\
&+ 2(1+r_1)D_i - (1+r_1)\sigma_2],
\end{aligned}
\tag{4.66}
$$

where i can be 1, 2, or 3, referring to one of the three groups for the second group of individuals that are described in Section 4.3.1.4. $D_1 = \mu_2$, $D_2 = X$, and $D_3 = Y$, where $D_3 \geq D_2 > D_1$. These indices are also applied to all the following derivations.

Note that $(1-2\epsilon)\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2 > -[\gamma(D_i+(1+r_1)I_1)+((1-\epsilon)\gamma+1)\sigma_2]$, and $\Delta_i < (1+r_1)^2[\gamma(D_i+(1+r_1)I_1)+((1-\epsilon)\gamma+1)\sigma_2]^2$, we have $\frac{(1+r_1)^2}{\sqrt{\Delta_i}}((1-2\epsilon)\gamma(D_i+(1+r_1)I_1) - ((1-\epsilon)\gamma+1)\sigma_2)\sigma_2 > -\frac{(1+r_1)^2}{1+r_1}\frac{\gamma(D_i+(1+r_1)I_1)+((1-\epsilon)\gamma+1)\sigma_2}{\gamma(D_i+(1+r_1)I_1)+((1-\epsilon)\gamma+1)\sigma_2}\sigma_2 = -(1+r_1)\sigma_2$. Therefore, it turns out $\frac{(1+r_1)^2}{\sqrt{\Delta_i}}((1-2\epsilon)\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2)\sigma_2+2(1+r_1)D_i-(1+r_1)\sigma_2 > 2(1+r_1)D_i - 2(1+r_1)\sigma_2 > 0$ given that $D_3 \geq D_2 > D_1 > \sigma_2$ by definition. On the other hand, $\frac{1}{\gamma} - \frac{1}{1+\gamma} > 0$. Hence, we have $\frac{\partial s_{1,i}^*}{\partial \gamma} > 0$, and $\frac{\partial c_{1,i}^*}{\partial \gamma} < 0$. Then $\frac{\partial s_{1,i}^*}{\partial \beta} > 0$, and $\frac{\partial c_{1,i}^*}{\partial \beta} < 0$. Individuals will save more and consume less if they value the future more (i.e., the discount parameters are larger). It is consistent with the situation in absence of NRSPI.

(2) Life Expectancy at Age 16

As I have argued, life expectancy has a perfect positive correlation with life expectancy parameter, b. Hence, I focus on analyzing b instead of life expectancy.

From Group 1 to Group 3, b gradually increases. The individual's willingness to participate in NRSPI increases with life expectancy, so does the level of contribution. While s_1^* and c_1^* change with b in Group 2, they stay constant in Group 1 and 3 since I assume the logarithm functional form.[13]

In period 2, there is a trade-off between so called "substitution effect" and "income effect". Specifically, the "substitution effect" makes the individual with longer life expectancy consume less and save more in period 1 to ensure more cash available in the future. On the other side, the "income effect" leads the individual with longer life expectancy to consume more and save less in period 1, since she expects to receive more NRSPI benefits given the same level of contribution. Hence, I need to decide the overall effect of life expectancy on consumption and savings in period 1.

Let us start with calculating the partial derivative of $s_{1,2}^*$ w.r.t. X:

$$\frac{\partial s_{1,2}^*}{\partial X} = \frac{1}{2A_2}\{-(1+r_1)(\gamma+2) + \frac{(1+r_1)^2\gamma}{\sqrt{\Delta_2}}[\gamma(X+(1+r_1)I_1) - ((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]\}. \tag{4.67}$$

Since I can rewrite Δ_2 as $\Delta_2 = (1+r_1)^2\{[\gamma(X+(1+r_1)I_1) - ((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]^2 + 4\epsilon[(1-\epsilon)\gamma+1-\epsilon]\}$, it is obvious that $\Delta_2 > (1+r_1)^2[\gamma(X+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]^2$. Suppose $\gamma(X+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2 < 0$, then $\frac{(1+r_1)^2\gamma}{\sqrt{\Delta_2}}[\gamma(X+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2] < 0$, and $\frac{\partial s_{1,2}^*}{\partial X} < \frac{1}{2A_2}\{-(1+r_1)(\gamma+2) < 0$. Suppose $\gamma(X+(1+r_1)I_1) - ((1-\epsilon)\gamma+1-2\epsilon)\sigma_2 > 0$, we know $\frac{(1+r_1)^2\gamma}{\sqrt{\Delta_2}}[\gamma(X+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2] < \frac{(1+r_1)\gamma}{\gamma(X+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2}[\gamma(X+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2] = (1+r_1)\gamma$. Therefore, I also obtain $\frac{\partial s_{1,2}^*}{\partial X} < -\frac{1+r_1}{A_2} < 0$. It is then straightforward that $\frac{\partial c_{1,2}^*}{\partial X} = -\frac{\partial s_{1,2}^*}{\partial X} > 0$. Noting that $\frac{\partial X}{\partial b} = \frac{a+M}{1+r_2} > 0$, we know $\frac{\partial s_{1,2}^*}{\partial b} < 0$ and $\frac{\partial c_{1,2}^*}{\partial b} > 0$.

[13] Recall that the representative individual does not participate in NRSPI in Group 1, and saves nothing in period 2 in Group 3. There is no combination of savings approaches in these two groups.

To conclude, consumption will increase and savings will decrease in period 1 as life expectancy increases, which means the "income effect" dominates. In other words, individuals who make minimum NRSPI contributions tend to consume more and save less at young age if they expect themselves to live longer and enjoy more NRSPI benefits.

It is worth noting that the model supporting the comparative static results assumes the realization of g_2 is totally random and not correlated with LE. If, for instance, the probability of incurring disability is negatively correlated with life expectancy, we know from equations (4.56), (4.59), and (4.62) that individuals with higher life expectancy tend to save less in period 1 since they have a higher expected disposable income in period 2. As a result, values of s_1^* for Group 1 and 3 individuals are decreasing in LE. As for individuals in Group 2, the reduction in s_1^* is even larger under this assumption.

Life expectancy also influences individuals' participation decisions, holding other parameters constant. When life expectancy is very low, individuals will not participate in NRSPI. As life expectancy increases, individuals switch from not participating to participating with minimum contribution. If life expectancy is high enough, individuals will contribute more than the minimum. Hence, life expectancy is a key individual parameter that determines participation decisions.

(3) Initial Cash on Hand

The partial derivatives of s_1^* w.r.t. I_1 for the three groups are:

$$\frac{\partial s_{1,i}^*}{\partial I_1} = \frac{1}{2A_i}\{(1+r_1)^2\gamma + \frac{(1+r_1)^3\gamma}{\sqrt{\Delta_i}}[\gamma(D_i + (1+r_1)I_1) - ((1-\epsilon)\gamma + 1 - 2\epsilon)\sigma_2]\}. \quad (4.68)$$

I have proved that $\Delta_2 > (1+r_1)^2[\gamma(X+(1+r_1)I_1) - ((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]^2$, which can be applied to the other two groups. Thus, $\Delta_i > (1+r_1)^2[\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]^2$.

First I suppose $\gamma(D_i + (1+r_1)I_1) - ((1-\epsilon)\gamma + 1 - 2\epsilon)\sigma_2 > 0$, then $\frac{(1+r_1)^3\gamma}{\sqrt{\Delta_i}}[\gamma(D_i + (1+r_1)I_1) - ((1-\epsilon)\gamma + 1 - 2\epsilon)\sigma_2]\} > 0$, and $\frac{\partial s_{1,i}^*}{\partial I_1} > \frac{(1+r_1)^2\gamma}{2A_i} > 0$. Besides, we also have $\frac{\partial s_{1,i}^*}{\partial I_1} < \frac{(1+r_1)^2\gamma+(1+r_1)^2\gamma}{2A_i} = \frac{(1+r_1)^2\gamma+(1+r_1)^2\gamma}{(1+r_1)^2(1+\gamma)} < 1$, which indicates that $\frac{\partial c_{1,i}^*}{\partial I_1} = 1 - \frac{\partial s_{1,i}^*}{\partial I_1} > 0$.

Second, I suppose $\gamma(D_i + (1 + r_1)I_1) - ((1 - \epsilon)\gamma + 1 - 2\epsilon)\sigma_2 < 0$, we have $\sqrt{\Delta_i} > -(1 + r_1)[\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]$. This leads to the inequality that $\frac{(1+r_1)^3\gamma}{\sqrt{\Delta_i}}[\gamma(D_i+(1+r_1)I_1) - ((1 - \epsilon)\gamma + 1 - 2\epsilon)\sigma_2] > (1 + r_1)^3\gamma\frac{\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2}{-(1+r_1)[\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]} = -(1 + r_1)^2\gamma$, which means $\frac{\partial s^*_{1,i}}{\partial I_1} > \frac{1}{2A_i}[(1 + r_1)^2\gamma - (1 + r_1)^2\gamma] = 0$. Thus, we always have $\frac{\partial s^*_{1,i}}{\partial I_1} > 0$. Meanwhile, I also demonstrate $\frac{\partial s^*_{1,i}}{\partial I_1} < \frac{(1+r_1)^2\gamma}{2A_i} = \frac{(1+r_1)^2\gamma}{(1+r_1)^2(1+\gamma)} < 1$, which means $\frac{\partial c^*_{1,i}}{\partial I_1} = 1 - \frac{\partial s^*_{1,i}}{\partial I_1} > 0$.

I can conclude that initial cash on hand positively affect both consumption and savings in period 1. Given more cash on hand, individuals tend to split the extra amount into current consumption and future savings, which is consistent with the intuition.

(4) Income and Income Shock

When it comes to income parameters, I focus on income and income shock in period 2, i.e., μ_2 and σ_2.

It is interesting to find out that the derivatives w.r.t. μ is almost identical to what I have done for life expectancy parameter. So I would like to simplify my derivations and quickly discuss the results. The partial derivatives w.r.t. μ_2 in the three groups are:

$$\frac{\partial s^*_{1,i}}{\partial \mu_2} = \frac{1}{2A_i}\{-(1 + r_1)(\gamma + 2) + \frac{(1 + r_1)^2\gamma}{\sqrt{\Delta_i}}[\gamma(D_i + (1 + r_1)I_1) - ((1 - \epsilon)\gamma + 1 - 2\epsilon)\sigma_2]\}. \tag{4.69}$$

Following the same logic, I show that $\frac{\partial s^*_{1,i}}{\partial \mu_2} < 0$ and $\frac{\partial c^*_{1,i}}{\partial \mu_2} > 0$. Individuals save less and consume more in period 1 once they expect to earn more money in period 2, which is intuitive.

As for the income shock, I also calculate the partial derivatives of $s^*_{1,i}$ w.r.t. σ_2:

$$\begin{aligned}\frac{\partial s^*_{1,i}}{\partial \sigma_2} =& \frac{1}{2A_i}\{(1 + r_1)((1 - \epsilon)\gamma + 1) + \frac{(1 + r_1)^2((1 - \epsilon)\gamma + 1)}{\sqrt{\Delta_i}}[-(\gamma(D_i + (1 + r_1)I_1) \\ &- ((1 - \epsilon)\gamma + 1)\sigma_2) + \frac{2\epsilon\gamma(D_i + (1 + r_1)I_1)}{(1 - \epsilon)\gamma + 1}]\}.\end{aligned} \tag{4.70}$$

Suppose that $\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2<0$, then $\frac{\partial s^*_{1,i}}{\partial\sigma_2}>\frac{1}{2A_i}(1+r_1)((1-\epsilon)\gamma+1)>0$. Suppose that $\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2>0$, then $\gamma(D_i+(1+r_1)I_1)>((1-\epsilon)\gamma+1)\sigma_2$, which means $-(\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2)+\frac{2\epsilon\gamma(D_i+(1+r_1)I_1)}{(1-\epsilon)\gamma+1}>-(\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2)+\frac{2\epsilon((1-\epsilon)\gamma+1)\sigma_2}{(1-\epsilon)\gamma+1}=-(\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2)$. At the same time, I have already shown that $\sqrt{\Delta_i}>(1+r_1)[\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]$. Combing the results, I obtain $\frac{(1+r_1)^2((1-\epsilon)\gamma+1)}{\sqrt{\Delta_i}}[-(\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2)+\frac{2\epsilon\gamma(D_i+(1+r_1)I_1)}{(1-\epsilon)\gamma+1}]>\frac{-(1+r_1)((1-\epsilon)\gamma+1)[\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2]}{\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1-2\epsilon)\sigma_2}=-(1+r_1)((1-\epsilon)\gamma+1)$. Therefore, we also have $\frac{\partial s^*_{1,i}}{\partial\sigma_2}>\frac{1}{2A_i}(1+r_1)[(1-\epsilon)\gamma+1-(1-\epsilon)\gamma-1]=0$. It is then straightforward that $\frac{\partial c^*_{1,2}}{\partial\sigma_2}=-\frac{\partial s^*_{1,2}}{\partial\sigma_2}<0$.

As we can observe, individuals will transfer some consumption to savings in period 1 when the negative income shock in period 2 is larger. They take care of the risk in income by saving more, which does not affect any participation decision.

Finally, I discuss the partial derivative of $s^*_{1,i}$ on the probability of disability, i.e., ϵ:

$$\frac{\partial s^*_{1,i}}{\partial\epsilon}=\frac{1}{2A_i}\{-(1+r_1)\gamma\sigma_2+\frac{(1+r_1)^2\gamma\sigma_2}{\sqrt{\Delta_i}}[(\gamma+2)(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2]\}. \tag{4.71}$$

We need to be aware that $(\gamma+2)(D_i+(1+r_1)I_1)>(\gamma+2)(\sigma_2+(1+r_1)I_1)>(\gamma+2)\sigma_2>((1-\epsilon)\gamma+1)\sigma_2$, implying $(\gamma+2)(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2>0$. In the meantime, $(1+r_1)^2[(\gamma+2)(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2]^2=(1+r_1)^2\{[\gamma(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2]^2+4\epsilon\gamma(D_i+(1+r_1)I_1)+4(1+\gamma)[(D_i+(1+r_1)I_1)(\gamma(D_i+(1+r_1)I_1)-\sigma_2)]\}>\Delta_i$, which indicates $\sqrt{\Delta_i}<(1+r_1)[(\gamma+2)(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2]$. Hence, $\frac{\partial s^*_{1,i}}{\partial\epsilon}>\frac{1}{2A_i}\{-(1+r_1)\gamma\sigma_2)+\frac{(1+r_1)^2\gamma\sigma_2}{(1+r_1)[(\gamma+2)(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2]}[(\gamma+2)(D_i+(1+r_1)I_1)-((1-\epsilon)\gamma+1)\sigma_2]\}=\frac{1}{2A_i}[-(1+r_1)\gamma\sigma_2+(1+r_1)\gamma\sigma_2]=0$. And $\frac{\partial c^*_{1,2}}{\partial\epsilon}=-\frac{\partial s^*_{1,2}}{\partial\epsilon}<0$.

Similar with the conclusion for the income shock, higher probability of disability in period 2, indicating higher risk in income, will make individuals save more and consume less in period 1.

4.3.1.7 Comparative Statics in Period 1: Policy Parameters

Policy parameters not only affect participation decisions, but also influence optimal values. Similar with the individual parameters, I discuss the effects of each policy parameter on savings and consumption.

(1) Monthly Basic Pension Payment

The monthly basic pension payment, denoted by k, only appears in the model via the basic pension parameter, denoted by a. Since $a = k \times T$, I only need to focus on a once I keep all the other parameters constant.

Examining the three participation decisions for three groups in Section 4.3.1.4, I find that the value of a plays a role in the trade-off between not participating and participating with minimum contribution when life expectancy is not too high. The higher a is, the greater the proportion of individuals that will participate in NRSPI with minimum contribution. Therefore, enhancing monthly basic pension payment will increase the NRSPI participation rate, although all the new participants will only contribute at the lowest level.

As for the effects on optimal values, a is only present in parameters X and Y, which means it affects optimal values in Group 2 and 3. In addition, $\frac{\partial X}{\partial a} = \frac{b}{1+r_2} > 0$, and $\frac{\partial Y}{\partial a} = 1 > 0$, indicating a has the same qualitative effects as X and Y. Recalling what I have demonstrated in Section 4.3.1.6, we know $\frac{\partial s^*_{1,i}}{\partial a} < 0$ and $\frac{\partial c^*_{1,i}}{\partial a} > 0$, where $i = 2, 3$. It directly follows that $\frac{\partial s^*_{1,i}}{\partial k} < 0$ and $\frac{\partial c^*_{1,i}}{\partial k} > 0$. In a word, higher monthly basic pension payment enables individuals who participate in NRSPI to save less and consume more in period 1, because they expect to receive more amount of money after turning 60.

(2) Minimum Total Contribution

Minimum contribution, denoted by M, also affects the trade-off between not participating and participating with minimum contribution. The higher M is, the less proportion of individuals will participate in NRSPI with minimum contribution, which is opposite to the effect of a. Hence, increasing minimum contribution level forces a portion of individuals to switch from participating at minimum level to not participating.

As we can observe, M affects optimal values when individuals contribute at the minimum level, as is described in Group 2 in Section 4.3.1.4. Both M and b appears in the parameter X, and the only difference is that $\frac{\partial X}{\partial M} = \frac{b}{1+r_2} - 1 \leq 0$. As a result, $\frac{\partial s_{1,2}^*}{\partial M}$ should have the opposite sign to $\frac{\partial s_{1,2}^*}{\partial X}$, which means $\frac{\partial s_{1,2}^*}{\partial M} > 0$, and correspondingly $\frac{\partial c_{1,2}^*}{\partial M} < 0$.

Higher level of minimum contribution for NRSPI reduces individuals' consumption in period 1, since they need to save more to meet the minimum contribution requirement, and meanwhile maintain consumption and savings in period 2.

(3) Policy-Specified Life Span after 60

Now I consider the impact of changing T. By definition, $\frac{\partial a}{\partial T} = k > 0$, and $\frac{\partial b}{\partial T} = -\frac{12\times 1\{LE\geq 60\}(LE-60)}{T^2} \leq 0$, indicating that T is positively correlated with a and negatively correlated with b, but the negative effect on b dominates in terms of the value of $b(a+M)$. Therefore, increasing T reduces monthly as well as total NRSPI benefits, resulting in not only lower NRSPI participation rate, but less portion of individuals contributing more than the minimum.

As for the optimal values, T has nothing to do with the optimal values in Group 1. In Group 2, both a and b affect X, but I can rewrite X as $X = \frac{12\times 1\{LE\geq 60\}(LE-60)k+bM-(1+r_2)M}{1+r_2}$, which means T actually affects X only by affecting b. Therefore, I obtain $\frac{\partial s_{1,2}^*}{\partial T} > 0$, and $\frac{\partial c_{1,2}^*}{\partial T} < 0$. Longer specified life span makes individuals with minimum contribution to save more and consume less in period 1, since they expect to receive lower benefits in period 3. In Group 3, only a appears in the parameter Y, meaning that $\frac{\partial s_{1,2}^*}{\partial T} < 0$, and $\frac{\partial c_{1,2}^*}{\partial T} > 0$. For those with high life expectancy, longer specified life span leads them to save less and consume more in period 1, since they find contributing to NRSPI less beneficial. Consequently, their incentives to save for NRSPI contribution reduce, and they prefer consuming more in young age to saving more for the future.

(4) Long-Term Normalized Interest Rates for Savings

Finally I look at long-term normalized interest rates for savings in the model, i.e., r_1 and r_2. Increasing long-term normalized savings rate in period 2 not only reduces the

NRSPI participation rate, but also discourages individuals from contributing more than the minimum. High normalized savings rate in period 2 makes more individuals prefer private savings to participating in NRSPI. Normalized savings rate in period 1, however, does not affect participation decisions. Hence, given the market savings rate, raising NRSPI interest rate (corresponding to lower normalized savings rate) encourages individuals to participate in NRSPI and contribute at higher levels.

Now I turn to explore the effects of savings rates on optimal values. First, I focus on r_1. Looking at equations (4.56), (4.59), and (4.62), we can see that, for all the three groups, increasing r_1 will make the right-hand side values larger but not influence the left-hand side. In order to equal the two sides, I need to increase the value of $s^*_{1,i}$. As a result, we have $\frac{\partial s^*_{1,1}}{\partial r_1} > 0$, $\frac{\partial s^*_{1,2}}{\partial r_1} > 0$, and $\frac{\partial s^*_{1,3}}{\partial r_1} > 0$. Increasing long-term savings rate in period 1 makes individuals save more and consume less in period 1. A higher savings rate in period 1 makes it more attractive to shift consumption forward to periods 2 and 3, for a given discount parameter. The substitution effect overshadows the income effect in this case.

On the other hand, r_2 affects optimal values when individuals contribute at the minimum level by affecting the value of X, which is similar with M. Since $\frac{\partial X}{\partial r_2} = \frac{-b(1+M)}{(1+r_2)^2} < 0$, we know $\frac{\partial s^*_{1,2}}{\partial r_2}$ should have the opposite sign to $\frac{\partial s^*_{1,2}}{\partial X}$. Therefore, $\frac{\partial s^*_{1,2}}{\partial r_2} > 0$, and correspondingly $\frac{\partial c^*_{1,2}}{\partial r_2} < 0$. Increasing savings rate in period 2 renders individuals who participate at the minimum contribution to save more and consume less in period 1.

4.3.1.8 Comparative Statics in Period 1: Discussion

I summarize the comparative static analysis in period 1 by first showing the proportional changes in participation decisions as the values of policy parameters increase in Table 4.3. Instead of the proportion of individuals in Group 2, I am more interested in the entire participation rate which is the sum of proportions for Group 2 and 3. I do not include life expectancy in this table since it is an individual parameter whose effect on participation decisions is only applied to a specific individual.

I proceed to present the changes of optimal savings and consumption in period 1 for the individuals sticking to the same group when the values of parameters increase in Table 4.4. This time, all the individual, policy parameters are included since optimal values vary across individuals.

Table 4.3: Proportional Changes of Individuals with Different Participation Decisions When the Value of One Policy Parameter Increases

	Proportions of Individuals		
Parameter	Not Participating	Participating	Participating beyond Minimum
k	$\downarrow$	$\uparrow$	$\rightarrow$
M	$\uparrow$	$\downarrow$	$\rightarrow$
T	$\uparrow$	$\downarrow$	$\downarrow$
r_1	$\rightarrow$	$\rightarrow$	$\rightarrow$
r_2	$\uparrow$	$\downarrow$	$\downarrow$

Table 4.4: Changes of Optimal Savings and Consumption within the Same Group in Period 1 When the Value of One Parameter Increases

	Group 1	Group 2	Group 3
Parameter	Not Participating	Participating at M	Participating beyond M
Individual Parameters			
β	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$
LE	$s_1^* \rightarrow$, $c_1^* \rightarrow$	$s_1^* \downarrow$, $c_1^* \uparrow$	$s_1^* \rightarrow$, $c_1^* \rightarrow$
I_1	$s_1^* \uparrow$, $c_1^* \uparrow$	$s_1^* \uparrow$, $c_1^* \uparrow$	$s_1^* \uparrow$, $c_1^* \uparrow$
μ_2	$s_1^* \downarrow$, $c_1^* \uparrow$	$s_1^* \downarrow$, $c_1^* \uparrow$	$s_1^* \downarrow$, $c_1^* \uparrow$
σ_2	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$
ϵ	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$
Policy Parameters			
k	$s_1^* \rightarrow$, $c_1^* \rightarrow$	$s_1^* \downarrow$, $c_1^* \uparrow$	$s_1^* \downarrow$, $c_1^* \uparrow$
M	$s_1^* \rightarrow$, $c_1^* \rightarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \rightarrow$, $c_1^* \rightarrow$
T	$s_1^* \rightarrow$, $c_1^* \rightarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \downarrow$, $c_1^* \uparrow$
r_1	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$
r_2	$s_1^* \rightarrow$, $c_1^* \rightarrow$	$s_1^* \uparrow$, $c_1^* \downarrow$	$s_1^* \rightarrow$, $c_1^* \rightarrow$

To conclude, I have solved for the optimal values of s_1 in different groups that have different participation decisions based on life expectancy at age 16 as well as policy parameters including monthly basic pension payment, minimum total contribution, policy-specified life span, and long-term savings rates. Using s_1^*, all the other optimal values (i.e., c_1^*, c_2^*, c_3^*, s_2^*,

p_1^*, and p_2^*) can be determined correspondingly. The factors listed above, as well as individual parameters including discount parameters, initial cash on hand, income and income shock, all have effects on optimal savings and consumption in period 1.

4.3.1.9 Comparative Statics in Period 2

With the help of comparative static analyses already done for period 1 and figures above, I am able to do some comparative static analyses for period 2. Consistent with period 1, I first discuss individual parameters, and then turn to policy parameters.

The most unique individual parameter in this model is life expectancy at age 16, i.e., LE. As I have shown, I can focus on b instead. In period 1, b negatively affects s_1^* for individuals in Group 2, but is irrelevant with s_1^* for the other groups. Since s_2^* is positively correlated with s_1^*, we know the decrease in s_2^* as b increases is even larger for Group 2 once I allow s_1^* to change. The qualitative results obtained from Figure 4.6 and 4.7, however, do not change. Among the individuals who contribute at the minimum, higher life expectancy renders them to save less and consume more in period 2. The other two groups are not affected. To explain this counter-intuitive result, I treat NRSPI contribution as an alternative form of savings. As life expectancy increases, this type of "savings" becomes more beneficial in the future. Therefore, an individual can acquire the same amount of money in period 3 with less private savings in period 2. Since we have shown the values of s_1^* for all groups are decreasing in LE when the realization of g_2 is informative about life expectancy, it directly follows that the values of s_2^* for all groups are also decreasing in LE.

For the remaining parameters, I aim to evaluate how their changes affect optimal values in period 2 that are presented in Table 4.1. In particular, I am interested in s_2^* for Group 1 and 2, and p_2^* for Group 3, because they are interior solutions which are subject to the changes of parameters.

When β increases, s_2^* will increase for Group 1 and 2, and p_2^* will increase for Group 3 if s_1^* stays constant. At the same time, in fact, s_1^* is also increasing in β. Therefore, the increases in s_2^* and p_2^* are reinforced.

When I_1 increases, s_2^* and p_2^* will not be affected if s_1^* stays constant. Since s_1^* is increasing in I_1, we know s_2^* will increase for Group 1 and 2, and p_2^* will increase for Group 3.

According to the definition of g_2 in equation (4.4), g_2 is solely increasing in μ_2 if no disability incurs, but increasing in μ_2 and decreasing in σ_2 if disability incurs. The value of g_2 is not influenced by ϵ in both cases. When μ_2 increases, g_2 will definitely increase in both cases. However, s_1^* is decreasing in μ, which goes towards the opposite direction as g_2. Hence, I ought to compare these two effects. Suppose that $\Delta\mu_2 = d > 0$ and $\Delta s_1^* = -\frac{d}{1+r_1} < 0$, the LHS values of equations (4.56), (4.59), and (4.62) will decrease while the RHS values stay constant, which indicates that $\Delta s_1^* > -\frac{d}{1+r_1}$. As a result, $\Delta g_2 + (1+r_1)\Delta s_1^* > 0$, which means s_2^* will increase for Group 1 and 2, and p_2^* will increase for Group 3.

When σ_2 increases, s_1^* will increase. For the individual without disability, g_2 stays constant, and then s_2^* will increase if she is in Group 1 or 2, p_2^* will increase if she is in Group 3. For the individual with disability, g_2 will decrease. Suppose $\Delta\sigma_2 = d > 0$ and $\Delta s_1^* = \frac{d}{1+r_1} > 0$, the LHS values of equations (4.56), (4.59), and (4.62) increase while the RHS values decrease. To equal both sides again, I need $\Delta s_1^* < \frac{d}{1+r_1}$, which in turn yields $\Delta g_2 + (1+r_1)\Delta s_1^* < 0$, and thus s_2^* will decrease for Group 1 and 2 and p_2^* will decrease for Group 3 if disability incurs. As we can see, the changes in s_2^* or p_2^* are opposite for individuals with and without incurring disability in period 2.

When ϵ increases, s_1^* will increase, which in turn results in the increases of s_2^* for Group 1 and 2, and p_2^* for Group 3.

Now let us discuss policy parameters. Individuals may switch to other groups when a policy parameter changes, and we need to keep in mind that I am interested in the individuals who stay in the same group before and after changes. It is meaningless to compare optimal values for those who change the participation decisions.

When k increases, s_1^* for Group 2 and 3 will decrease. The increase in a strengthens this effect in period 2. As a result, s_2^* will decrease for Group 2, and p_2^* will decrease for Group 3. What is more, increasing a will also move the first threshold, i.e., $\frac{(1+r_2)M}{a+M}$, to the left in

Figure 4.6 and 4.7.

When M increases, s_1^* will increase for Group 2. Suppose $\Delta M = d > 0$ and $\Delta s_1^* = \frac{1+\beta^\theta}{\beta^\theta(1+r_1)} d > 0$, the LHS value of equation (4.59) increases while the RHS value decreases, Hence, it must be the case that $\Delta s_1^* < \frac{1+\beta^\theta}{\beta^\theta(1+r_1)} d$, which indicates $\frac{\beta^\theta}{1+\beta^\theta}(1+r_1)\Delta s_1^* - \Delta M < 0$ and thus s_2^* is decreasing in M for Group 2. On the contrary, $p_2^* = M$ will increase for certain.[14] In addition, increasing M will move the first threshold, i.e., $\frac{(1+r_2)M}{a+M}$, to the right in Figure 4.6 and 4.7.

The impacts of T are more complicated since it is related with b. When T increases, a will increase and b will decrease. Some individuals switch from Group 2 to Group 1, and some switch from Group 3 to Group 2. Let us suppose there are original parameters T, a, and b. If $\Delta T = d > 0$, then $\Delta a = \frac{d}{T} a > 0$, and $\Delta b = -\frac{d}{T+d} b < 0$. Individuals in Group 1 will not be affected at all. An individual who remains in Group 2 will have higher s_1^*, and then her $\Delta s_2^* = \frac{\beta^\theta(1+r_1)(1+r_2)\Delta s_1^* + \frac{d}{T+d} bM}{(1+\beta^\theta)(1+r_2)} > 0$. Therefore, s_2^* will increase for individuals sticking to Group 2. On the other side, An individual who remains in Group 3 will have lower s_1^*, and her $\Delta p_2^* = \frac{\beta^\theta(1+r_1)\Delta s_1^* - \frac{d}{T} a}{1+\beta^\theta} < 0$. Thus, p_2^* will decrease for individuals remaining in Group 3. The heterogeneity in the changes of s_2^* and p_2^* comes from the fact that individuals in Group 3 contribute much more than those in Group 2, hence the impact of T on Group 3 individuals are more substantial.

Finally I discuss normalized savings rates. When r_1 increases, s_1^* will increase for all groups. It directly follows that $(1+r_1)s_1^*$ will also increase. Therefore, s_2^* will increase in Group 1 and 2, and p_2^* will increase in Group 3.

When r_2 increases, only individuals in Group 2 increase s_1^* accordingly, which leads their s_2^* to increase. Furthermore, both thresholds, i.e., $\frac{(1+r_2)M}{a+M}$ and $1+r_2$, will move to the right in Figure 4.6 and 4.7.

I summarize the changes in s_2^* and p_2^* when the values of parameters increase in Table 4.5. Note that ND means the individual is not disabled, and D means the individual is disabled.

[14] It is also straightforward that $s_2^* + p_2^*$ is increasing in M.

To conclude, changes in the parameters tend to affect optimal savings or contribution in period 2 in both direct and indirect ways. On the one hand, some parameters directly appear in the equations for optimal solutions in period 2. On the other hand, the effects on optimal savings in period 1 are transferred to period 2 by changing the total cash on hand.

Table 4.5: Changes of Optimal Values within the Same Group in Period 2 When the Value of One Parameter Increases

	Group 1	Group 2	Group 3
Parameter	Not Participating	Participating at M	Participating beyond M
Individual Parameters			
β	$s_2^* \uparrow$	$s_2^* \uparrow$	$p_2^* \uparrow$
LE	$s_2^* \rightarrow$	$s_2^* \downarrow$	$p_2^* \rightarrow$
I_1	$s_2^* \uparrow$	$s_2^* \uparrow$	$p_2^* \uparrow$
μ_2	$s_2^* \uparrow$	$s_2^* \uparrow$	$p_2^* \uparrow$
σ_2	$s_2^* \uparrow$ (ND); $s_2^* \downarrow$ (D)	$s_2^* \uparrow$ (ND); $s_2^* \downarrow$ (D)	$p_2^* \uparrow$ (ND); $p_2^* \downarrow$ (D)
ϵ	$s_2^* \uparrow$	$s_2^* \uparrow$	$p_2^* \uparrow$
Policy Parameters			
k	$s_2^* \rightarrow$	$s_2^* \downarrow$	$p_2^* \downarrow$
M	$s_2^* \rightarrow$	$s_2^* \downarrow$ ($p_2^* \uparrow$)	$p_2^* \rightarrow$
T	$s_2^* \rightarrow$	$s_2^* \uparrow$	$p_2^* \downarrow$
r_1	$s_2^* \uparrow$	$s_2^* \uparrow$	$p_2^* \uparrow$
r_2	$s_2^* \rightarrow$	$s_2^* \uparrow$	$p_2^* \rightarrow$

I single out each parameter and analyze the comparative statics one by one in period 1 and period 2. Even if I include the maximum contribution, the majority of qualitative results are still valid. Results from these analyses serve as testable hypotheses which can be tested and discussed in depth with simulation and empirical estimation.

4.3.2 Individuals without Perfect Foresight

Instead of assuming individuals know exactly how long they will live, now I assume they are uncertain about their life expectancy until period 3. Specifically, the life expectancy at 16, LE, is no longer a constant, but follows a distribution with the probability density function $h(LE)$, which has a lower support m and an upper support n, and $m < n$. It directly follows that the expected value of LE is $\int_m^n th(t)\,dt$. I assume the difference between n and m is less than 15, which means $n - m < T_2 < T_1$. It is an important assumption since it ensures that expected life expectancy can at most be in two periods.

I would like to focus on the individuals who expect to possibly reach 60, i.e., $n > 60$. I still need to start with period 3 to see how this change influences the optimization.

4.3.2.1 Period 3

The individual who lives to period 3 just consumes all cash on hand, no matter the exact life expectancy she has. Therefore, the decisions are the same as those in Section 4.3.1.1, except the fact that the life expectancy parameter, $b = \frac{12\times(LE-60)}{T}$, has a range due to uncertainty about LE. The probability density function for b is $\phi(b) = h(\frac{T}{12}b + 60)$ when $b > 0$, and $\phi(b) = \frac{\max\{0,60-m\}}{n-m}$ when $b = 0$. The lower support and upper support for b are $\max\{0, \frac{12\times(m-60)}{T}\}$ and $\frac{12\times(n-60)}{T}$, respectively. Thus, we have:

$$c_3^{**} = (1 + r_2)s_2 + 1\{p_2 \geq M\}b(a + p_2). \tag{4.72}$$

And the utility function in period 3 is:

$$u(c_3^{**}) = ln[(1 + r_2)s_2 + 1\{p_2 \geq M\}b(a + p_2)]. \tag{4.73}$$

As for the individual dies before period 3, there is no utility in period 3, which can be treated as zero.

4.3.2.2 Period 2

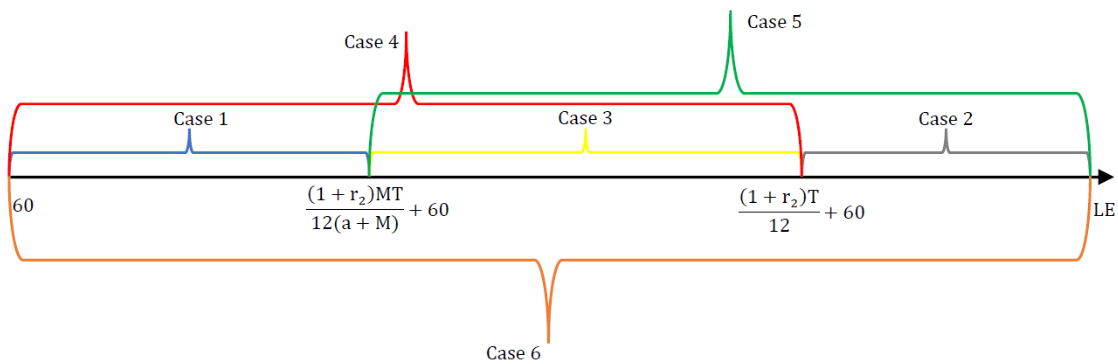
At the start of period 2, the individual only knows the distribution of LE, and therefore the distribution of b. If the lower bound $m > 60$, the individual will definitely live to period 3, and b is always larger than zero. If $m \leq 60$, the individual might die in period 2. Then we have $b = 0$ with the probability of $\frac{60-m}{n-m}$, and $b > 0$ with the probability of $\frac{n-60}{n-m}$.

Let us first consider the individual with $m \geq 60$, which means she will definitely live to period 3. Her optimization problem in period 2 becomes:

$$W_2(s_1, g_2) = \max_{s_2,p_2} ln[g_2+(1+r_1)s_1-p_2-s_2]+\beta^\theta E_2[ln[(1+r_2)s_2+1\{p_2 \geq M\}b(a+p_2)]]. \tag{4.74}$$

Compared with the perfect foresight case, the major difference is that utility in period 3 is no longer fixed and expected utility for period 3 needs to be calculated. Regarding the newly added expectation, I need to discuss case by case according to different values of m and n. Figure 4.20 illustrates the six cases and corresponding ranges for LE.

Figure 4.20: Cases and Corresponding Ranges for Life Expectancy



(1) Case 1: $n \leq \frac{(1+r_2)MT}{12(a+M)} + 60$

In this case, the individual will not participate in NRSPI since $b < 1+r_2$ and $b(a+M) \leq (1+r_2)M$ are always satisfied. Thus we have $p_2^{**} = 0$ and the optimization problems becomes:

$$W_2(s_1, g_2) = \max_{s_2} \; ln[g_2 + (1+r_1)s_1 - s_2] + \beta^{\theta} E_2[ln[(1+r_2)s_2]], \tag{4.75}$$

where there is no b involved and $E_2[ln[(1+r_2)s_2]] = ln[(1+r_2)s_2]$. Then I obtain the same solutions for s_2 and c_2 as Section 4.3.1.2:

$$s_2^{**} = \frac{\beta^{\theta} g_2 + \beta^{\theta}(1+r_1)s_1}{1+\beta^{\theta}}, \tag{4.76}$$

$$c_2^{**} = g_2 + (1+r_1)s_1 - s_2^{**} = \frac{g_2 + (1+r_1)s_1}{1+\beta^{\theta}}. \tag{4.77}$$

For the individual whose maximum life expectancy is not much higher than 60, introducing uncertainty about life expectancy does not affect her optimization in period 2.

The value function in this case is:

$$W_2(s_1, g_2) = ln(\frac{g_2 + (1+r)s_1}{1+\beta^\theta}) + \beta^\theta ln[\beta^\theta (1+r_2)\frac{g_2 + (1+r_1)s_1}{1+\beta^\theta}]. \tag{4.78}$$

(2) Case 2: $m > \frac{(1+r_2)T}{12} + 60$

In this case, the individual will participate in NRSPI beyond minimum contribution since $b > 1 + r_2$, which means $s_2^{**} = 0$. The optimization problem becomes:

$$W_2(s_1, g_2) = \max_{p_2} \ ln[g_2 + (1+r_1)s_1 - p_2] + \beta^\theta E_2[ln[b(a+p_2)]]. \tag{4.79}$$

Since $ln[b(a+p_2)] = ln(b) + ln(a+p_2)$, we know $E_2[ln[b(a+p_2)]] = E_2[ln(b)] + ln(a+p_2)$, which means the variation in b does not affect the optimization of p_2 since there is no b present when I take partial derivative w.r.t. p_2. Hence, I obtain the same result as Section 4.3.1.2 again:

$$p_2^{**} = \frac{\beta^\theta (g_2 + (1+r_1)s_1) - a}{1+\beta^\theta}, \tag{4.80}$$

$$c_2^{**} = \frac{g_2 + (1+r_1)s_1 + a}{1+\beta^\theta}. \tag{4.81}$$

For the individual who expects to live much longer than 60 years for certain, uncertainty about the exact life expectancy has no impact on her optimization in period 2.

And the value function is:

$$W_2(s_1, g_2) = ln(\frac{g_2 + (1+r)s_1 + a}{1+\beta^\theta}) + \beta^\theta [\int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} ln(b)\phi(b)\, db + ln(\frac{\beta^\theta (g_2 + (1+r_1)s_1 + a)}{1+\beta^\theta})]. \tag{4.82}$$

(3) Case 3: $m > \frac{(1+r_2)MT}{12(a+M)} + 60$ **and** $n \leq \frac{(1+r_2)T}{12} + 60$

In this case, the individual will participate in NRSPI at minimum contribution, since $b \leq 1 + r_2$ and $(1+r_2)M < b(a+M)$ are always satisfied. As a result, $p_2^{**} = M$, and the optimization problem becomes:

$$W_2(s_1, g_2) = \max_{s_2}\ ln[g_2 + (1 + r_1)s_1 - M - s_2] + \beta^\theta E_2[ln[(1 + r_2)s_2 + b(a + M)]]. \quad (4.83)$$

The new FOC by taking partial derivative w.r.t. s_2 is:

$$E_2[\frac{\beta^\theta(1 + r_2)}{(1 + r_2)s_2 + b(a + M)}] = \frac{1}{g_2 + (1 + r_1)s_1 - M - s_2}, \quad (4.84)$$

where $E_2[\frac{\beta^\theta(1+r_2)}{(1+r_2)s_2+b(a+M)}] = \int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} \frac{\beta^\theta(1+r_2)}{(1+r_2)s_2+b(a+M)}\phi(b)\, db.$[15]

Using equation (4.84), I solve for the optimal value of s_2:

$$s_2^{**} = f(s_1, g_2). \quad (4.85)$$

And optimal c_2 is:

$$c_2^{**} = g_2 + (1 + r_1)s_1 - M - f(s_1, g_2). \quad (4.86)$$

Uncertainty about life expectancy affects optimal savings and consumption in this case, although the participation decision remains unchanged. I can also derive the following value function:

$$W_2(s_1, g_2) = ln[g_2+(1+r_1)s_1-M-f(s_1, g_2)]+\beta^\theta \int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} ln[(1+r_2)f(s_1, g_2)+b(a+M)]\phi(b)\, db. \quad (4.87)$$

(4) Case 4: $m < \frac{(1+r_2)MT}{12(a+M)} + 60$ **and** $\frac{(1+r_2)MT}{12(a+M)} + 60 < n \leq \frac{(1+r_2)T}{12} + 60$

Now I face a more complicated case where $b \leq 1 + r_2$ is still satisfied but $b(a + M)$ can be either higher or lower than $(1 + r_2)M$. Therefore, the individual needs to choose between not participating and participating at minimum contribution.

To be specific, the individual must compare the indirect utilities calculated for both can-

[15] Although $E_2[\frac{\beta^\theta(1+r_2)}{(1+r_2)s_2+b(a+M)}]$ is equal to $\beta^\theta(1 + r_2)E_2[\frac{1}{(1+r_2)s_2+b(a+M)}]$, it cannot be rewritten as $\frac{\beta^\theta(1+r_2)}{(1+r_2)s_2+E_2[b(a+M)]}$, which is the reason that I do not simplify the LHS in equation (4.84).

didate decisions, which are equation (4.78) and equation (4.87), respectively. The individual will participate in NRSPI at minimum contribution and have optimal savings and consumption derived in case 3 if and only if $W_2(s_1, g_2)$ in equation (4.87) is larger than $W_2(s_1, g_2)$ in equation (4.78), or equivalently:[16]

$$ln[g_2 + (1 + r_1)s_1 - M - f(s_1, g_2)] + \beta^\theta \int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} ln[(1 + r_2)f(s_1, g_2) + b(a + M)]\phi(b)\, db$$

$$> ln(\frac{g_2 + (1 + r)s_1}{1 + \beta^\theta}) + \beta^\theta ln[\beta^\theta (1 + r_2)\frac{g_2 + (1 + r_1)s_1}{1 + \beta^\theta}]. \tag{4.88}$$

Otherwise, the individual will not participate in NRSPI and have optimal savings and consumption derived in case 1. Furthermore, there is no possibility for a third participation decision where p_2^{**} is neither 0 nor M in this case, since the individual will never contribute a non-zero amount that is less than M.

(5) Case 5: $\frac{(1+r_2)MT}{12(a+M)} + 60 < m \leq \frac{(1+r_2)T}{12} + 60$ **and** $n > \frac{(1+r_2)T}{12} + 60$

In this case, $(1 + r_2)M < b(a + M)$ all the time, but the comparison between b and $1 + r_2$ is ambiguous. Hence, the individual will choose between participating at and beyond minimum contribution once I limit the participation decisions to already existing ones.

Once again, the individual should compare the indirect utilities calculated in equation (4.82) and equation (4.87). The individual will participate in NRSPI beyond minimum contribution and have optimal savings and consumption derived in case 2 if and only if $W_2(s_1, g_2)$ in equation (4.82) is larger than $W_2(s_1, g_2)$ in equation (4.87), or equivalently:

$$ln(\frac{g_2 + (1 + r)s_1 + a}{1 + \beta^\theta}) + \beta^\theta [\int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} ln(b)\phi(b)\, db + ln(\frac{\beta^\theta (g_2 + (1 + r_1)s_1 + a)}{1 + \beta^\theta})]$$

$$> ln[g_2 + (1 + r_1)s_1 - M - f(s_1, g_2)] + \beta^\theta \int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} ln[(1 + r_2)f(s_1, g_2) + b(a + M)]\phi(b)\, db. \tag{4.89}$$

[16] Note that whenever $m < 60$, we have $\phi(b) = 0$.

Otherwise, the individual will participate in NRSPI at minimum contribution and have optimal savings and consumption derived in case 3.

However, we need to be aware that this conclusion is valid when I assume there are only two options for the individual, where either $s_2^{**} = 0$ or $p_2^{**} = M$. Actually, thanks to uncertainty, the individual can have new alternative solutions where $s_2^{**} > 0$ and $p_2^{**} > M$ by solving the following two FOCs:

$$E_2[\frac{\beta^\theta(1+r_2)}{(1+r_2)s_2 + b(a+p_2)}] = \frac{1}{g_2 + (1+r_1)s_1 - p_2 - s_2}, \tag{4.90}$$

$$E_2[\frac{\beta^\theta b}{(1+r_2)s_2 + b(a+p_2)}] = \frac{1}{g_2 + (1+r_1)s_1 - p_2 - s_2}. \tag{4.91}$$

I define the solutions to equations (4.90) and (4.91) as the function of s_1 and g_2:

$$s_2^{**} = \rho(s_1, g_2), \tag{4.92}$$

$$p_2^{**} = \eta(s_1, g_2). \tag{4.93}$$

We know the solutions must satisfy the following equation:

$$\begin{aligned} &\int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} \frac{\beta^\theta(1+r_2)}{(1+r_2)\rho(s_1,g_2) + b(a+\eta(s_1,g_2))}\phi(b)\,db \\ =&\int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} \frac{\beta^\theta b}{(1+r_2)\rho(s_1,g_2) + b(a+\eta(s_1,g_2))}\phi(b)\,db. \end{aligned} \tag{4.94}$$

And optimal consumption in period 2 is:

$$c_2^{**} = g_2 + (1+r_1)s_1 - \eta(s_1,g_2) - \rho(s_1,g_2). \tag{4.95}$$

The corresponding value function is:

$$W_2(s_1, g_2) = ln[g_2 + (1 + r_1)s_1 - \eta(s_1, g_2) - \rho(s_1, g_2)] + \beta^\theta \int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} ln[(1 + r_2)\rho(s_1, g_2) + b(a + \eta(s_1, g_2))]\phi(b)\, db. \tag{4.96}$$

As long as I can find interior solutions where $\rho(s_1, g_2) > 0$, $\eta(s_1, g_2) > M$ and $\eta(s_1, g_2) + \rho(s_1, g_2) \leq g_2 + (1+r_1)s_1$, the individual will choose this alternative participation decision, i.e., saving some amount and contributing more than the minimum at the same time. Otherwise, the individual will continue to choose between the two original participation decisions based on equation (4.89).

(6) Case 6: $m < \frac{(1+r_2)MT}{12(a+M)} + 60$ **and** $n > \frac{(1+r_2)T}{12} + 60$

The last case involves all the three original participation decisions, and also the new participation decision with interior solutions, as I have discussed in case 5. It is because the comparisons between $(1 + r_2)M$ and $b(a + M)$, as well as b and $1 + r_2$, are both uncertain.

As a result, the individual needs to compare indirect utilities in four equations, i.e., equation (4.78), (4.82), (4.87), and (4.96), and pick the largest one. Then the corresponding participation decision will be optimal for the individual.

4.3.2.3 Period 1

The optimization problem in period 1 is the same as equation (4.52). In period 1, the individual is uncertain about the realized income in period 2, i.e., g_2.[17] The binding FOC (4.53) and equation (4.55) yield the following equation:

$$\frac{1}{I_1 - s_1} = (1 - \epsilon)\beta^\theta \frac{\partial W_2(s_1, \mu_2)}{\partial s_1} + \epsilon\beta^\theta \frac{\partial W_2(s_1, \mu_2 - \sigma_2)}{\partial s_1}. \tag{4.97}$$

Once I solve for s_1^{**}, the expected utility in period 1 is:

$$EU = ln(I_1 - s_1^{**}) + \beta[(1 - \epsilon)W_2(s_1^{**}, \mu_2) + \epsilon W_2(s_1^{**}, \mu_2 - \sigma_2)], \tag{4.98}$$

[17] Thus, uncertainty in period 1 is different from uncertainty in period 2.

where $W_2(s_1^{**}, \mu_2)$ is the period 2 value function for the optimal participation decision.

Similar with period 2, I am supposed to discuss optimization in period 1 case by case.

(1) Case 1: $n \leq \frac{(1+r_2)MT}{12(a+M)} + 60$

Whenever the individual decides not to participate in NRSPI, the optimal values of s_1 and c_1 will be no longer related to b. Thus, optimization should be identical to case 1 in Section 4.3.1.4. Equation (4.97) will change to equation (4.56), and the solutions will be equations (4.57) and (4.58).

(2) Case 2: $m > \frac{(1+r_2)T}{12} + 60$

Similar with the previous case, variation in life expectancy also has no effect on the value function if the individual always save nothing and contribute more than the minimum in period 2. Plugging equation (4.82) in equation (4.97) and reorganizing, I obtain the equation that is identical to equation (4.62). As a result, the solutions will be equations (4.63) and (4.64).

(3) Case 3: $m > \frac{(1+r_2)MT}{12(a+M)} + 60$ **and** $n \leq \frac{(1+r_2)T}{12} + 60$

As I have argued, the individual will contribute M to be eligible for NRSPI in this case, and the value function in period 2 is equation (4.87), whose partial derivative w.r.t. s_1 is now dependent on b. Plugging equation (4.87) into equation (4.97) and using the similar approach as case 2 in Section 4.3.1.4, I acquire:

$$s_1^{**} = \zeta(IP, PP), \tag{4.99}$$

where IP refer to individual parameters, and PP are policy parameters. It naturally follows that $0 \leq \zeta(IP, PP) \leq I_1$. Whenever $\zeta(IP, PP)$ equals 0 or I_1, we have corner solutions in period 1. Henceforth, all the values of s_1^{**} are also subject to this constraint.

The consumption in period 1 is therefore:

$$c_1^{**} = I_1 - s_1^{**} = I_1 - \zeta(IP, PP). \tag{4.100}$$

(4) Case 4: $m < \frac{(1+r_2)MT}{12(a+M)} + 60$ **and** $\frac{(1+r_2)MT}{12(a+M)} + 60 < n \leq \frac{(1+r_2)T}{12} + 60$

Since the individual need to choose between two participation decisions, the most straightforward method is to first calculate the value of s_1 that makes the individual indifferent between the two decisions, which is denoted as s_1^{ind} and can be obtained by solving:

$$ln[g_2 + (1+r_1)s_1 - M - f(s_1, g_2)] + \beta^\theta \int_{\frac{12(m-60)}{T}}^{\frac{12(n-60)}{T}} ln[(1+r_2)f(s_1, g_2) + b(a+M)]\phi(b)\, db$$
$$= ln(\frac{g_2 + (1+r)s_1}{1+\beta^\theta}) + \beta^\theta ln[\beta^\theta (1+r_2)\frac{g_2 + (1+r_1)s_1}{1+\beta^\theta}]. \tag{4.101}$$

Then, suppose the individual chooses to not participate in NRSPI, her interior solution for optimal savings in period 1 is equation (4.57), denoted by $s_1^{int,\prime}$. Once $s_1^{int,\prime}$ does not satisfy inequality (4.88), her savings in period 1 if not participating, denoted by s_1', equals $s_1^{int,\prime}$ (interior solution). Otherwise, her s_1' equals s_1^{ind} (corner solution). Plugging s_1' as well as equation (4.78) in equation (4.98), I calculate the corresponding expected utility EU'.

Similarly, suppose the individual chooses to participate in NRSPI at minimum contribution, her interior solution for optimal savings in period 1 is equation (4.99), denoted by $s_1^{int,\prime\prime}$. Once $s_1^{int,\prime\prime}$ satisfies inequality (4.88), her savings in period 1 if participating at M, denoted by s_1'', equals $s_1^{int,\prime\prime}$ (interior solution). Otherwise, her s_1'' equals s_1^{ind} (corner solution). Plugging s_1'' as well as equation (4.87) in equation (4.98), I calculate the expected utility EU''.

The individual will make final decision by comparing EU' and EU''. If $EU' > EU''$, she will not participate in NRSPI and $s_1^{**} = s_1'$. Otherwise, she will participate at minimum contribution and $s_1^{**} = s_1''$. Under both circumstances, $c_1^{**} = I_1 - s_1^{**}$.

(5) Case 5: $\frac{(1+r_2)MT}{12(a+M)} + 60 < m \leq \frac{(1+r_2)T}{12} + 60$ **and** $n > \frac{(1+r_2)T}{12} + 60$

I first consider whether the individual can have interior solutions in period 2, i.e., saving a non-zero amount and contributing beyond minimum. Suppose there are interior solutions for both s_2 and p_2, then the individual will definitely choose this option and value function in period 2 is therefore equation (4.96). Plugging this value function into equation (4.97), I solve for:

$$s_1^{**} = \psi(IP, PP). \tag{4.102}$$

If I am unable to find interior solutions in period 2, then the individual will choose between contributing M and saving more than zero, and contributing beyond M and saving nothing. The process is exactly the same as the previous case, which I do not want to elaborate repetitively. Optimal savings in period 1 are denoted as s_1'' and s_1''' for the two options. The corresponding expected utilities are EU'' and EU''', respectively. Once $EU'' > EU'''$, she will choose the former and $s_1^{**} = s_1''$.[18] Otherwise, she will choose the latter $s_1^{**} = s_1'''$.

No matter what participation decision the individual makes, her consumption in period 1 can always be calculated by $c_1^{**} = I_1 - s_1^{**}$.

(6) Case 6: $m < \frac{(1+r_2)MT}{12(a+M)} + 60$ **and** $n > \frac{(1+r_2)T}{12} + 60$

Similar with case 5, the individual will choose to save more than zero and contribute more than M if there exist interior solutions for s_2 and p_2. The value function is (4.96) and $s_1^{**} = \psi(IP, PP)$.

Otherwise, the individual needs to compare the expected utilities for the three participation decisions, as is derived previously: EU' for not participating, EU'' for participating at M, EU''' for participating beyond M and saving nothing. The decision with the highest expected utility will be chosen.

4.3.2.4 Discussion

Derivations get more complicated once I introduce uncertainty about life expectancy. Instead of three cases for optimization in the perfect foresight case, there are six cases in the imperfect foresight case.[19] One of the most significant changes is that there might be solutions where both savings and contribution are nonzero in period 2. They are more likely to occur in the individuals whose life expectancy is in the middle or has a large range. In

[18] I have defined s_1'' and EU'' in case 4, and I continue to use them in order to keep notations consistent.

[19] I focus on individuals who can possibly reach 60 years old.

addition, the distinction of different participation decisions is less clear since individuals may have heterogeneous participation decisions within the same range of life expectancy. The distribution of life expectancy plays an important role in making participation, savings, and consumption decisions. Once the distribution is given, derivations will be straightforward.

Nevertheless, most qualitative results obtained in the perfect foresight case also apply in the imperfect foresight case. Life expectancy is still the key individual parameter that affects participation decisions, and the effects of all parameters on optimal savings, consumption, and contribution should have the same signs.

The assumption of uncertainty also allows for underestimation or overestimation of life expectancy. For instance, a young individual who will die in an accident in the future probably overestimates her life expectancy. As a result, she may choose to participate in NRSPI, which is not her optimal decision. If most individuals overestimate life expectancy, the maximum NRSPI participation rate will be higher since more individuals expect to reach 60 years old. It may explain the reason why some rural residents do not behave optimally and the participation rate in reality is not the same as what is anticipated by the theory.

4.4 Life Expectancy and Utility in Period 3

In this conceptual model, the utility function in period 3 does not depend on life expectancy. To explore how the conceptual results change if utility in period 3 depends on life expectancy, I assume the optimization problem in period 3 is now:

$$\max_{c_3} \; l(LE)ln(c_3), \tag{4.103}$$

where $l(LE)$ is continuous and increasing in LE, with $l(60) \geq 0$.

If individuals know their life expectancy, participation decisions are not affected by introducing $l(LE)$ in period 3. However, this assumption does affect the optimization problem in period 2, which becomes:

$$W_2(s_1, g_2) = \max_{s_2,p_2} \; ln[g_2 + (1+r_1)s_1 - p_2 - s_2] + l(LE)\beta^\theta ln[(1+r_2)s_2 + 1\{p_2 \geq M\}b(a+p_2)]. \tag{4.104}$$

Comparing equation (4.104) with equation (4.27), we can see the only difference is that β^θ in equation (4.27) is replaced by $l(LE)\beta^\theta$ in equation (4.104). Consequently, β^θ is replaced by $l(LE)\beta^\theta$ in all the optimal solutions. Thus, the discount parameter β^θ can actually account for differences in life expectancy in period 3, as long as I allow θ to depend on LE and vary across individuals. Intuitively individuals who expect to live well past age 60 should and will rationally discount period 3 of life less than someone who anticipates a shorter life span.

The only comparative statics affected by this change are those for life expectancy, as LE may affect optimal values through $l(LE)$ and b now. According to Section 4.3.1.6, values of s_1^* for all the three groups are increasing in β^θ, which means s_1^* is also increasing in $l(LE)$ under the new assumption. Since individuals in Group 1 and 3 are not affected by b in period 1, I conclude that s_1^* in Group 1 and 3 will increase as LE increases. As for Group 2, I have shown s_1^* is decreasing in b. Hence, the sign of $\frac{\partial s_1^*}{\partial LE}$ is dependent on the comparison between the positive effect brought by higher marginal utility in period 3 (through $l(LE)$) and the negative effect brought by higher NRSPI benefits in period 3 (through b). I would need to specify the functional form of $l(\cdot)$ in order determine the sign.

Similar with period 1, optimal values of individuals in Group 1 and 3 are irrelevant to b in period 2. Since s_2^* for Group 1 and p_2^* for Group 3 are increasing in β^θ without the new assumption, it naturally follows that they are also increasing in LE. For individuals in Group 2, s_2^* is decreasing in b, but increasing in $l(LE)$, as well as s_1^*. As a result, determining the sign of $\frac{\partial s_2^*}{\partial LE}$ is more complicated since I also need to consider the impact of changing s_1^* besides the two effects I have mentioned above.

For individuals in Group 1 and 3 who either contribute nothing or save nothing in period 2, longer life expectancy means higher marginal utility in period 3 under the new assumption.

Hence, they save more in periods 1 and 2. The comparative statics for Group 2 individuals become more complicated because life expectancy affects savings through two different channels.

If individuals are uncertain about their life expectancy, the optimization problem in period 2 under the new assumption becomes:

$$W_2(s_1, g_2) = \max_{s_2, p_2} ln[g_2 + (1+r_1)s_1 - p_2 - s_2] + \beta^\theta E_2[l(LE) ln[(1+r_2)s_2 + 1\{p_2 \geq M\} b(a+p_2)]]. \tag{4.105}$$

While Figure 4.20 is still applicable, optimal values in each case will change since the utility in period 3 is always uncertain even if the individual chooses to not participate in NRSPI. Thus, uncertain life expectancy introduces not only uncertain NRSPI benefits, but also uncertain utility in period 3. Nevertheless, the rules to make participation decisions remain unchanged.

To conclude, I argue that most conceptual findings, except the changes of optimal savings for Group 2 individuals as life expectancy increases, are not affected qualitatively when I assume utility in period 3 depends on life expectancy. I can account for elements of life expectancy by assigning different values of θ to individuals with different life expectancies. In addition, it is difficult to decide the specific functional form of $l(\cdot)$ that correctly reflect how life expectancy influences marginal utility of savings. Hence, I do not introduce this assumption in the following discussion.

Chapter 5

Simulation

I conduct a simulation analysis following the conceptual framework, mainly for five reasons. First, I aim to explore the proportions of residents for the three participation decisions. In the conceptual framework, I show how changing policy parameters affect individual participation decisions. Using the simulation, I can qualitatively verify my conceptual findings, and also quantitatively determine the heterogeneous effects of different parameters on different participation decisions. Elasticities of the NRSPI participation rate and proportion of contributing beyond minimum are calculated. Then I am able to decide which parameters can significantly affect the participation rate, and which parameters tend to influence the average contribution level. In addition, I am interested in the potential deviation of the optimal participation rate based on the economic theory from the rate observed in reality. Significant deviation could point to shortcomings in the model or to rural residents not behaving optimally, in which case policies to promote the NRSPI program and educate rural residents regarding its operation and benefits may be in order.

Second, I want to calculate optimal values for rural residents using the equations derived in the conceptual framework. With these values, I can precisely analyze the comparative statics and evaluate how much the parameters impact savings, consumption, and contribution. Similar with the case of participation rates, different parameters ought to have significantly heterogeneous effects on optimal values, not only in terms of the sign, but also in terms of the magnitude. What is more, the crowding out effect of NRSPI contribution is of great importance to study, since it determines whether NRSPI successfully enhances the consumption of participants in different periods and alleviates poverty.

Third, I plan to study the net expenditure of implementing NRSPI for the Chinese government, a factor that my conceptual framework has not discussed. With the optimal values, I am able to calculate net expenditures under different policy characterizations. I want to show how the net expenditure changes with parameters of interest, and which parameters have the dominant effect. I also calculate elasticities of net expenditure with respect to the parameters. More importantly, I present and discuss the trade-off between net government expenditure and the NRSPI participation rate. Policy parameters may have heterogeneous effects on these two, leading me to seek the optimal set of parameters that minimize the unit net expenditure for an extra percent of the participation rate. Based on the results, I argue that the government may choose different parameters to achieve various policy objectives.

Fourth, I analyze the regional heterogeneity of the participation rate, which is mainly caused by different values of average life expectancy and monthly basic pension payment across provinces. I utilize the data from the real world and calculate the participation rate in each province, showing how large the differences can be. In addition, I want to explain the reasons why this regional heterogeneity is inevitable.

Fifth, I discuss the effects of introducing the matching subsidy that is proportional to NRSPI contribution. Specifically, I make a comparison between raising monthly basic pension payment and increasing subsidy rate, to decide which method is more effective in terms of enhancing the participation rate, and which method stands out in terms of enhancing average contribution level.

Finally, the conceptual framework does not include the maximum contribution and assumes that residents can contribute whatever they have in period 2. In reality, however, there is a maximum level of contribution in place, as described in Section 2.4. I introduce the maximum contribution into the simulation model and examine how it affects optimal behaviors for residents in Group 3.

5.1 Simulation Parameters

I begin with the discussion of parameters that are listed in Section 4.3.1.5. For each parameter, I need to decide the range and/or distribution of its value that make sense in reality. I first discuss policy parameters since I do not need their distributions, and then turn to individual parameters.

5.1.1 Monthly Basic Pension Payment: k

Minimum basic pension payment is 55 yuan/month, which serves as the lower bound of k. The variation of basic pension payment across provinces tends to be large. In the richest provinces, such as Beijing, local governments have enhanced monthly basic pension payment to 820 yuan in year 2021, while some western provinces only provide minimum basic pension payment, i.e., 55 yuan/month. If I exclude the extreme values in some highly-urbanized prefectures (such as Beijing and Shanghai), the highest monthly basic pension payment is 310 yuan (which is the current value in Hangzhou prefecture in Zhejiang province). Therefore, the range of k in my simulation can be $[55, 310]$. For simulation, I pick sixteen alternative values for k from 55 to 310, with an increment of 17.

5.1.2 Minimum Total Contribution for Eligibility: M

The Chinese central government sets the minimum annual contribution for NRSPI to be 100 yuan. Since individuals are required to contribute no less than 15 years for eligibility, we have $M = 15 \times 100 = 1,500$ yuan, which serves as the lower bound. Hangzhou has increased its minimum annual contribution for NRSPI to 300 yuan in year 2021, which means $M = 15 \times 300 = 4,500$ yuan.[1] The range of M in my simulation is $[1,500, 4,500]$.

There is an overall positive relationship between k and M, but the correlation is not likely to be very high. Compared with the high heterogeneity of basic pension payment, the

[1]Similar to my argument for k, I exclude extreme values in some highly-urbanized prefectures.

variability of minimum contribution tends to be much lower across different prefectures. It is common for a prefecture to have basic monthly pension higher than 55 yuan but stick to the standard minimum annual contribution, i.e., 100 yuan. Because of this reason, I select only three alternative values for M in the simulation, which are 1,500, 3,000, and 4,500 yuan.

5.1.3 Policy-Specified Life Span after 60: T

Different from other policy parameters, currently specified life span after 60 for NRSPI is uniform across the country, which equals 139 months. It is worth noticing that, holding a and M constant, the less specified life span is, the higher monthly NRSPI payment will be. In other words, reducing specified life span after 60 will increase individual benefits at the cost of government expenditures. In my simulation, I plan to choose five alternative values for T that start at 99 and end at 179 months, with an increment of 20 months. Thus, $T = \{99, 119, 139, 159, 179\}$.

5.1.4 Long-Term Normalized Interest Rates for Savings: r_1 and r_2

Currently, the annual market savings rate for long-term savings ranges from 3.25% to 3.75% across the financial institutions in China. The average annual market savings rate is therefore 3.5%. Since annual NRSPI interest rate is lower than the annual market savings rate, and is changing with policy characterizations, I let its lower support be 0, and upper support be 2.0%.[2] By definition, annual normalized savings rate, denoted by $r^{one\ year}$, has the range from 1.5% to 3.5 %. For simulation, I draw five alternative values of $r^{one\ year}$ within the range of $[1.5\%, 3.5\%]$, thus, $r^{one\ year} = \{1.5\%, 2.0\%, 2.5\%, 3.0\%, 3.5\%\}$.

Assuming that in reality individuals save the same amount, $s_t^{one\ year}$, in each year of period t ($t = 1, 2$) at the uniform annual rate of $r^{one\ year}$, I calculate $s_1 = T_1 \times s_1^{one\ year}$ and $s_2 = T_2 \times s_2^{one\ year}$, where $T_1 = 29$ and $T_2 = 15$. Since the compounded savings at the end of

[2]Current one-year savings deposit rates in Chinese financial institutions vary from 1.5% to 1.75%. As I have described, NRSPI rate is usually the same as the one-year savings deposit rate, although regional disparities exist. Setting 2.0% as the upper support of NRSPI interest rate is consistent with the reality.

period t is defined as $(1 + r_t)s_t$ in the conceptual model, we have:

$$(1 + r_1)s_1 = s_1^{one\ year}(1 + r^{one\ year}) + \cdots + s_1^{one\ year}(1 + r^{one\ year})^{T_1}, \tag{5.1}$$

$$(1 + r_2)s_2 = s_2^{one\ year}(1 + r^{one\ year}) + \cdots + s_2^{one\ year}(1 + r^{one\ year})^{T_2}, \tag{5.2}$$

from which I solve for the closed-form equations of long-term normalized savings rate r_1 and r_2:

$$r_1 = \frac{(1 + r^{one\ year})^{T_1+1} - (1 + r^{one\ year})}{T_1 \times r^{one\ year}} - 1, \tag{5.3}$$

$$r_2 = \frac{(1 + r^{one\ year})^{T_2+1} - (1 + r^{one\ year})}{T_2 \times r^{one\ year}} - 1. \tag{5.4}$$

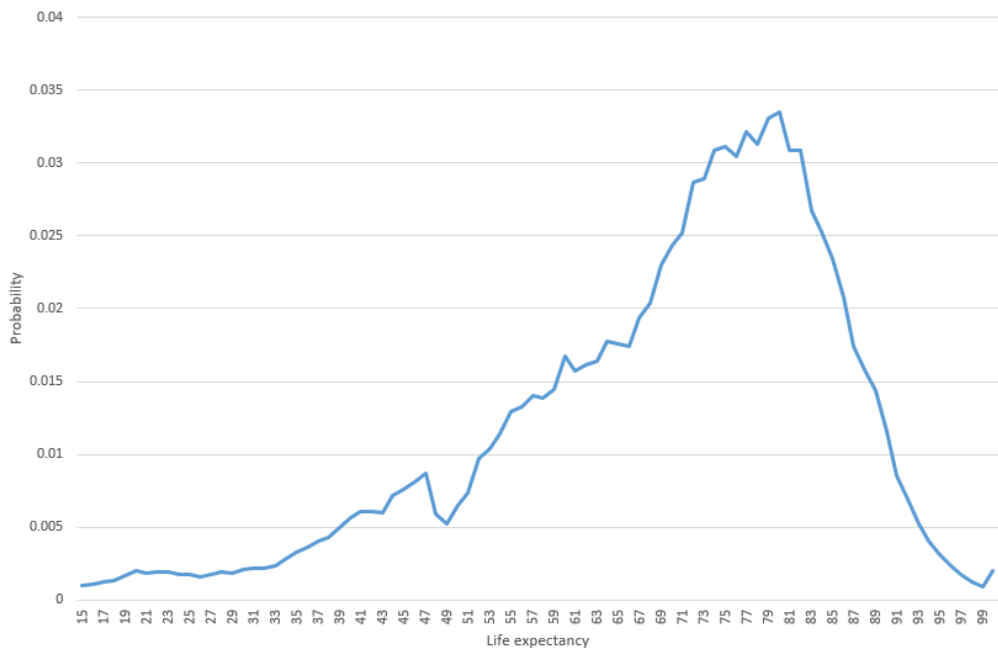
Applying the values of T_1 and T_2, I can calculate the ranges for r_1 and r_2, which are $[26.00\%, 74.56\%]$, and $[12.88\%, 33.14\%]$, respectively. r_1 is approximately twice as high as r_2, reflecting that T_1 is roughly twice as long as T_2.

5.1.5 Life Expectancy at 16: LE

Based on the conceptual model, period 1 starts when rural people enter the work force, thus, at age 16, which is also the minimum age requirement for NRSPI participation. It will be perfect if I have exact data of life expectancy at 16 in rural China. However, I am only able to access the data of average life expectancy at 15 for all Chinese people in year 2020, which is equal to 77.7 years. At the same time, average life expectancy at birth for all Chinese people is 77.1 years. In year 2010, the corresponding average life expectancy at 15 and at birth are 75.5 years and 74.9 years. Hence, average life expectancy at 15 and at birth both increase by 2.2 years from 2010 to 2020, based on which I can assume that life expectancy at 16 also increased by 2.2 years from 2010 to 2020.

I also obtain data on rural mortality rates in year 2010, from which I calculate that the average age of death for rural Chinese people over age 15 in 2010 is 69.19 years, which can be used as the approximation of life expectancy at 15. At the same time, approximated life expectancy at 16 in 2010 is 69.24 years, which is only 0.05 years higher than that at 15. The

Figure 5.1: Life Expectancy at 15 in Rural China in Year 2010



probabilities of life expectancy at 15 and at 16 for rural Chinese people are shown in Figure 5.1 and Figure 5.2, respectively. The corresponding standard deviations are 15.8 and 15.7 years. To summarize, the overall difference between life expectancy at 15 and life expectancy at 16 is trivial.

Figure 5.2: Life Expectancy at 16 in Rural China in Year 2010

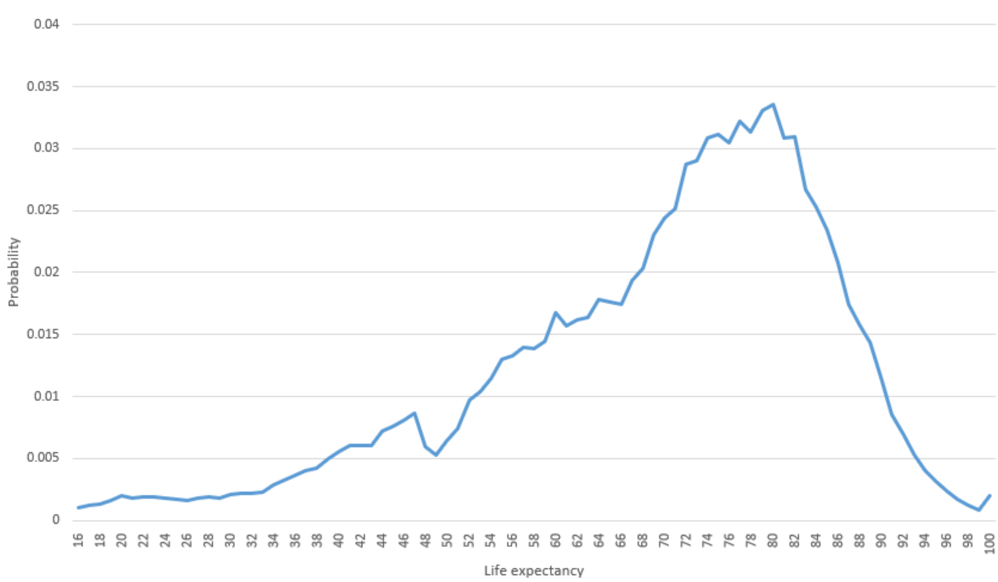
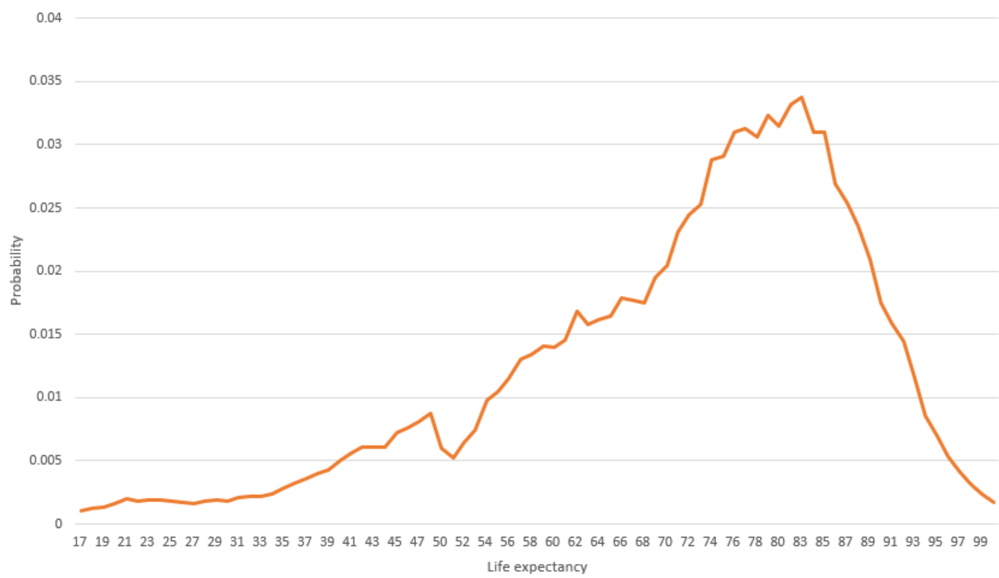


Figure 5.3: Estimated Life Expectancy at 16 in Rural China in Year 2020



The available information allows me to make estimates on life expectancy at 16 for rural Chinese people in 2020. First, I trim the population and select the group of individuals with life expectancy at 16 ranging from 16 to 97 according to the probabilities I have in year 2010. Thus, I exclude the individuals with life expectancy no less than 98, who account for only 0.4% of the rural population in 2010. The life expectancy at 16 for these rural Chinese people in 2010 has a mean of 69.1 and a standard deviation of 15.7, which show no significant difference from those of the entire population (69.2 and 15.7, correspondingly). Second, I calculate the average life expectancy in 2020, which is $69.1 + 2.2 = 71.3$. Third, I multiply the life expectancy values in 2010 by $\frac{71.3}{69.1}$ to obtain the estimated life expectancy values in 2020. By doing this, I actually obtain life expectancy estimates that have the similar shape of distribution as those in 2010, and have the mean of 71.3. The range of life expectancy at 16 in 2020 is therefore $[16.5, 100.1]$. Fourth, I use Figure 5.3 to present the probabilities of these estimates. The standard deviation for them is 16.3.

Then, I proceed to identify the probability distribution based on the data in Figure 5.3. One possible fitted distribution I propose is the generalized beta distribution of second kind, i.e., the GB2. There are several reasons to choose the GB2. First, the variable of interest, life expectancy at 16 (LE), is in theory left-truncated and semi-finite (thus, $LE \geq 16$), and the GB2 is supported on a semi-finite interval. Second, the GB2 nests a number of common distributions, such as Weibull, lognormal, generalized gamma, F, and log logistic distributions. Third, the GB2 has been used in modeling life expectancy for many years, typically in the form of hazard functions (McDonald and Richards, 1987).

The original GB2 distribution has the cumulative distribution function (CDF):

$$F(x) = IB(p_d, q_d, \frac{(x/b_d)^{a_d}}{1 + (x/b_d)^{a_d}}), \tag{5.5}$$

where a_d, b_d, p_d, and q_d are positive parameters for the random variable $x > 0$. Among the four parameters, a_d, p_d and q_d are shape parameters, and b_d is a scale parameter. $IB(\cdot, \cdot, \cdot)$ is the incomplete beta function.

I can then derive the probability density function of the GB2:

$$f(x) = \frac{a_d x^{a_d p_d - 1}}{b_d^{a_d p_d} B(p_d, q_d)(1 + (x/b_d)^{a_d})^{p_d + q_d}}, \tag{5.6}$$

where $B(p_d, q_d) = \frac{G(p_d)G(q_d)}{G(p_d+q_d)}$ is the beta function and $G(\cdot)$ is the gamma function.

Since in this simulation I only consider individuals with life expectancy no less than 16, we have the truncated CDF and PDF:

$$F(x|x \geq 16) = \frac{F(x) - F(16)}{1 - F(16)}, \tag{5.7}$$

$$f(x|x \geq 16) = \frac{f(x)}{1 - F(16)}. \tag{5.8}$$

Using the data of estimated life expectancy in 2020, I am able to identify the parameters for the GB2. Estimated Parameters (a_d, b_d, p_d, and q_d) and distributional statistics for the fitted distribution are shown in Table 5.1. I can find little difference between these statistics and those in Figure 5.3, which indicates that this distribution fits the data well.

Table 5.1: Estimated Parameters and Population Distributional Statistics for the GB2 Distribution of Life Expectancy at 16

Parameter	Estimated Value	Standard Error
a_d	20.80	18.51
b_d	95.70	21.74
p_d	0.1785	0.1706
q_d	3.10	10.66
Statistic	Estimated Value	Standard Error
Mean	71.04	1.80
Standard Deviation	16.04	1.34

The final step will be drawing LE values for simulation from the fitted GB2 distribution, which is denoted by $GB2(a_d, b_d, p_d, q_d)$. In theory, I make the random draws using the following four-step approach:

(1) I draw $X_{d,1}$ and $X_{d,2}$ from two independent χ^2 distributions with degree of freedom equaling $2p_d$ and $2q_d$, respectively.

(2) I generate $Y_d = \frac{X_{d,1}}{X_{d,2}}$.

(3) I take $Z_d = Y_d^{\frac{1}{a_d}}$.

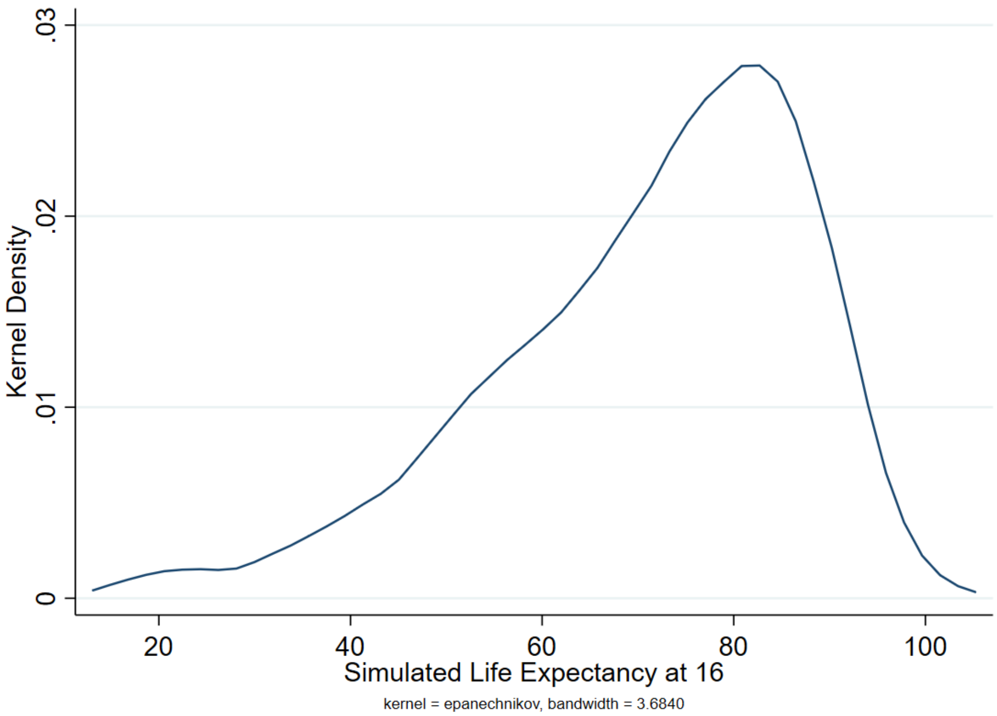
(4) I obtain $LE = b_d Z_d$.

The sample mean and standard deviation of the randomly drawn LE are 71.07 and 12.30, respectively. The Kernel density for simulated life expectancy values are shown in Figure 5.4. As we can observe, the shape and distributional statistics are similar with Figure 5.3. The lower density in Figure 5.4 is mainly due to the choice of bandwidth.

5.1.6 Discount Parameter: β

Based on the conceptual framework, the discount parameter from period 2 to period 1, denoted by β, is a compounded discount factor over a number of years. The discount parameter from period 3 to period 2 is represented by β^θ, where $0 < \theta < 1$ is a fixed number. Two assumptions made in my model should be emphasized before any further discussion. First, utilities in period t ($t = 1, 2, 3$) are measured at the start of each period, with the same logarithm utility form. Second, consumption in period t, i.e., c_t, is the aggregated consumption over the entire period. For instance, if I assume individuals consume the same

Figure 5.4: Kernel Density for Simulated Life Expectancy at 16



amount each year in period t, denoted by $c_t^{one\ year}$, then I have $c_t = T_t \times c_t^{one\ year}$, where T_t is the length of period t.[3]

To calculate β, I should first obtain the long term annual real discount rate, denoted by $d^{one\ year}$. As for the formula of β, two discounting models for utility functions that are widely used in economics are exponential and hyperbolic discounting models. While the former has a constant discount rate, the latter has a higher discount rate in the near future and a lower discount rate in the distant future. In the conceptual framework I utilize exponential discounting for simplicity's sake since θ will be the same ($\theta = \frac{T_2}{T_1}$) for all individuals. However, a rich vein of empirical evidence indicates that individuals do not discount utilities or rewards in an exponential way. Frederick, Loewenstein, and O'donoghue (2002) summarize the empirical research since the 1980s, and argue that hyperbolic discounting is superior to exponential discounting in many aspects. Hence, I adopt the hyperbolic discounting model

[3]We can see that β may contain more information than simply discount parameters, but the overall effects of other factors on the value of discount parameter are ambiguous. In addition, the logarithm utility function is also a special case of initial model setup. Therefore, I tend to not discuss these factors and still treat β as discount parameter.

to calculate β and β^θ:

$$\beta = \frac{1}{1 + d^{one\ year} \times T_1}, \tag{5.9}$$

$$\beta^\theta = \frac{1}{1 + d^{one\ year} \times T_2}, \tag{5.10}$$

where $T_1 = 29$ and $T_2 = 15$. As we can see, under hyperbolic discounting, θ varies with β, which means I need to calculate β and β^θ separately. For comparison, the exponential model calculates β and β^θ using the following equations:

$$\beta = \frac{1}{(1 + d^{one\ year})^{T_1}}, \tag{5.11}$$

$$\beta^\theta = \frac{1}{(1 + d^{one\ year})^{T_2}}. \tag{5.12}$$

In reality, individuals, especially individuals in developing countries, tend to discount at much higher rates than the one-year savings deposit rates. Studies on such implicit discount rates over a long period in developed countries indicate values ranging from 17.5% to 270% (Stevens, DeCoteau, and Willis, 1997; Warner and Pleeter, 2001; Harrison, Lau, and Williams, 2002; Kovacs and Larson, 2008; Bond, Cullen, and Larson, 2009). As for developing countries, Pender (1996) finds that annual discount rates are approximately from 26% to 119% in India. Botelho et al. (2006), however, estimate a much lower average annual discount rate of 12.7%. Tanaka, Camerer, and Nguyen (2010) obtain annual discount rates for money rewards with the range from 135% to 239%. Wang and He (2018) are the first to estimate discount rates in China and find the annual discount rates for an environmental protection project in the range from 141% to 315%. It seems that annual discount rates can be very high.

However, we also need to be aware that these studies focused on discount rates of monetary rewards or payments rather than utility. The discount rate in my model, however, should be applied to the CRRA utility of consumption on all types of goods. Andreoni and Sprenger (2012) argue that such MPL (multiple price lists) methods typically yield high average discount rates, mainly due to the assumption of linear utility and difference between risk and time preferences. To capture discounting and concavity at the same time, they employ the CTB (convex time budget) method and obtain the estimates of annual discount rate, ranging from 24.6% to 37.7%. It is worth noting, though, that this study also deals with time preferences for money, but not utility.

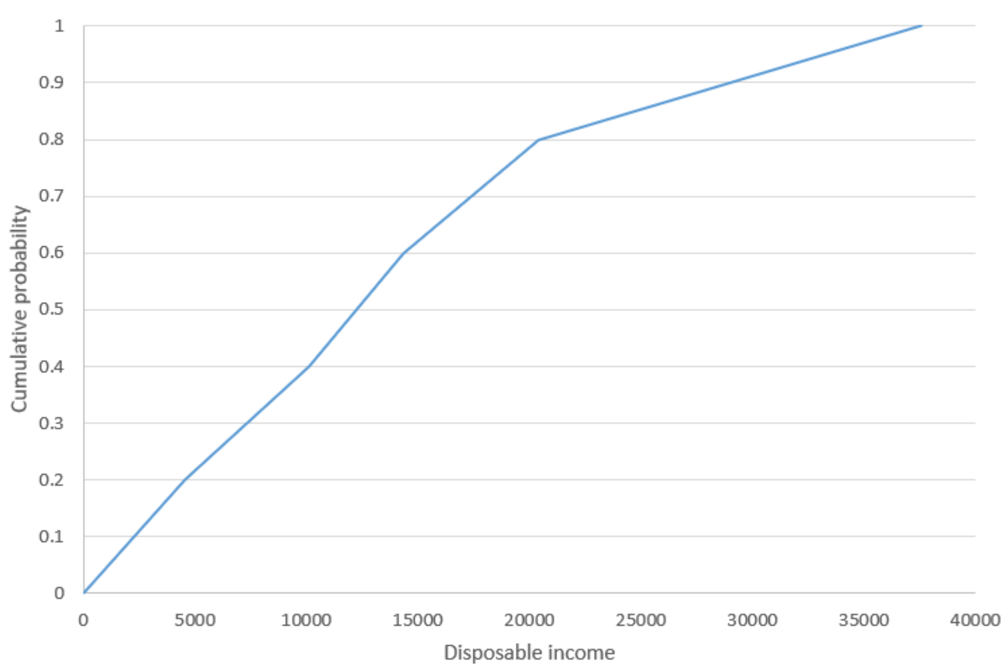
Turning to discounting utilities, Andersen et al. (2008) design several DMPL (double multiple price lists) experiments to obtain the estimates of exponential and hyperbolic annual discount rates, which are 10.1% and 10.3%, respectively. Using Brazilian data, Issler and Piqueira (2000) find that the annual discount parameter falls between 0.85 and 0.96. Thus, the range for $d^{one\ year}$ is $[4.2\%, 17.6\%]$. Ahmed, Haider, and Iqbal (2012) develop a general equilibrium model with utility maximization and demonstrate that steady state utility discount parameter equals $\frac{1}{d^{one\ year}}$. The authors also provide the estimate of annual discount parameters for several countries, which range from 0.9370 (Korea) to 0.9882 (Pakistan) if I exclude extreme values for Venezuela and Jamaica. Correspondingly, the range for $d^{one\ year}$ is $[1.2\%, 6.7\%]$. In addition, Andersen et al. (2014) point out that, allowing for concavity, estimated annual discount rates are similar for exponential discounting (8.9%) and simple hyperbolic discounting (8.85%).

For simulation, I use 1.5%, i.e., the one-year savings deposit rate, as the lower support of $d^{one\ year}$, and 10.3% from Andersen et al. (2008) as the upper support. I then draw the discount rate from a uniform distribution within this range, thus, $d^{one\ year} \sim U(1.5\%, 10.3\%)$. Finally I calculate the corresponding values for discount parameters β and β^{θ} with hyperbolic discounting based on equations (5.9) and (5.10). When $d^{one\ year} = 1.5\%$, I have shown that $\beta = 69.69\%$ and $\beta^{\theta} = 81.63\%$. When $d^{one\ year} = 10.3\%$, I obtain $\beta = 25.08\%$ and $\beta^{\theta} = 39.29\%$. Alternatively, the exponential discounting model yields similar values for β and β^{θ} when $d^{one\ year} = 1.5\%$ (64.64% and 79.99%), but much smaller values when $d^{one\ year} = 10.3\%$ (5.83% and 22.98%). Such differences also imply that hyperbolic discounting is preferable.

5.1.7 Expected Disposable Income and Income Shock in Period 2: μ_2 and σ_2

According to (National Bureau of Statistics of China, 2021a), the average annual disposable income excluding finance income is 16,712.7 yuan.[4] The yearbook also divided rural residents into five income quantiles and calculated average annual disposable income in each quantile, with which I am able to estimate that the standard deviation of disposable income is 12,676.15 yuan. In addition, I also graph the approximate cumulative probability of annual disposable income in Figure 5.5 based on the average number for each quantile. According to Figure 5.5, as well as previous studies on income inequality, we know the distribution for disposable income should be right-skewed.

Figure 5.5: Cumulative Probability of Annual Disposable Income in Rural China in 2020



Jäntti, Sierminska, and Van Kerm (2015) argue that a large range of income, especially when we consider the income for all quantiles of individuals, can be best fitted by lognormal, Singh-Maddala, Dagum, or GB2 distributions. Among these distributions, the GB2

[4]Average finance income is 418.8 yuan, accounting for 2.5% of average disposable income. Remember that in the conceptual framework, the disposable income does not include any income from savings. And savings income is the major component of finance income for rural residents in China.

is the best-fitting 4-parameter distribution, which better represents most of the distributions of disposable household income per capita than the Dagum and Singh-Maddala models (Brzeziński, 2013; Hlasny, 2021). Hence, I use the GB2 distribution again to identify the distribution of disposable income, μ_2. The intuition and procedure are similar to Section 5.1.5. Estimated Parameters and statistics for the fitted $GB2(a, b, p, q)$ distribution are shown in Table 5.2.

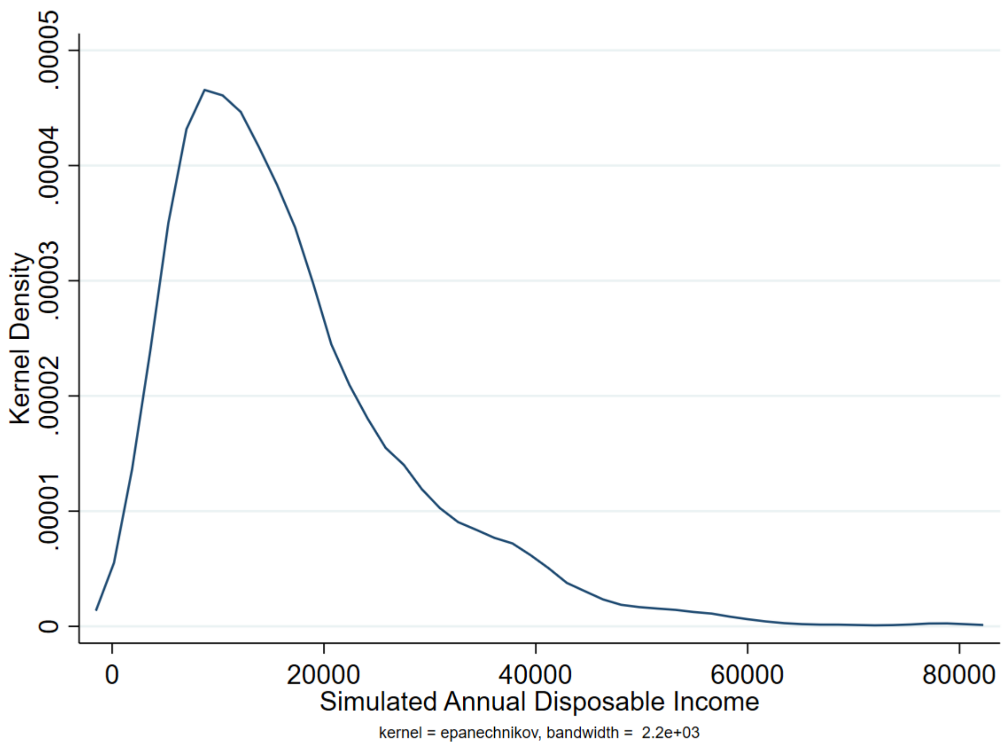
Table 5.2: Estimated Parameters and Population Distributional Statistics for the GB2 Distribution of Annual Disposable Income

Parameter	Estimated Value
a	0.56
b	4.18×10^9
p	6.90
q	7,326.44
Statistic	Estimated Value
Mean	17,425.93
Standard Deviation	12,128.16

I can then draw annual disposable income, denoted by μ_{2a}, from this fitted distribution. The sample mean and standard deviation of the drawn μ_{2a} are 16,997.9 and 11,374.4, respectively. The Kernel density for simulated disposable income values is shown in Figure 5.6. As we can observe, all the distributional statistics are similar with the real data. For instance, the difference between estimated and real average disposable income is around 2%. The expected disposable income in period 2, i.e., μ_2, is therefore $\mu_2 = T_2 \times \mu_{2a} = 15\mu_{2a}$ for the individuals with $LE \geq 60$. For individuals with $45 \leq LE < 60$ have $\mu_2 = (LE - 45)\mu_{2a}$, and the individuals with $LE < 45$ have $\mu_2 = 0$ instead. I do not draw annual disposable income from the distribution for 15 times and then sum them up, because the disposable income for an individual in year $t + 1$ is not totally random, but highly correlated with the income in year t.

Alternatively, since lognomal distribution could provide good fit to incomes that are relatively low (Kmietowicz and Ding, 1993), I fit a lognormal distribution with mean and standard deviation equal to 17,732.73 and 14,190.69. The population means and standard deviations of the two fitted distributions are calculated using the estimated parameters, because of which they are different from the real data. Comparing the GB2 and lognomal distributions, I conclude that the GB2 fits the real data better.

Figure 5.6: Kernel Density for Simulated Annual Disposable Income in Period 2



Since all periods consist of many years, the mean of stochastic income shocks is likely to be zero since they can cancel out each other in the long term. Consistent with the conceptual framework, I focus on the permanent income shock, which is related with income disability and is therefore negative.

According to the Second National Survey of Disabled Persons (SNSDP) conducted in 2006 by the National Bureau of Statistics, there were 82.96 million disabled people in 2005, accounting for 6.34% of the population in China. This percentage was higher if I focus on rural China, where 62.25 million out of 731.6 million people (thus, 8.51%) were disabled. In terms of age groups, around 1.31% of people from age 0 to 14, 3.94% of people from age 15 to 59, and 25.89% of people older than 60 were disabled. On average, rural residents who had at least one family member with disability earned per capita annual (gross) income equal to 2,260 yuan in 2005, while those who had no disabled family member earned 4,852 yuan. Hence, the ratio of average income for disabled people and non-disabled people, denoted by ρ, can be estimated by $\frac{2260}{4852} = 0.466$. Loyalka et al. (2014) further divide households in terms of number of adults, finding that the corresponding ratio for one-adult household is $\rho = \frac{3153}{6884} = 0.458$. The similar estimates of ρ using different sub-samples strongly support the validity of such approach.

On the other hand, Chen, Lv, and Chen (2013) employ data from the monitoring report on disabled people's situation and well-off progress in China in 2013, and present results from which I am able to estimate the ratio. From year 2007 to 2012, the values of ρ range between 0.463 and 0.548. The estimates for ρ, though exhibiting a upward sloping in general, do not change dramatically or monotonically from year to year.

It is worth noting that different data sources might have different definition on disability and income measurement, which provide a good explanation for the variation of estimates. For example, SNSDP defines disability according to a biomedical model rather than a social model, resulting in a lower disability rate compared with those that classify disability using social models. Hence, I use the ratio obtained from Loyalka et al. (2014), i.e., 0.458, as the lower support of ρ, and the ratio from Chen, Lv, and Chen (2013), i.e., 0.548, as the upper support. The annual income shock due to disability, σ_{2a}, is therefore within the range of $[(1-0.548)\mu_{2a}, (1-0.458)\mu_{2a}] = [0.452\mu_{2a}, 0.542\mu_{2a}]$. For each individual i, I draw $\sigma_{2a,i}$ from the uniform distribution $U(0.452\mu_{2a,i}, 0.542\mu_{2a,i})$.

If an individual incurs disability, her annual disposable income drops from μ_{2a} to $\mu_{2a} - \sigma_{2a}$ permanently. Since individuals incur disability from age 15 to 59 with the probability of 3.94%, the annual probability of incurring disability is $\frac{3.94}{45}\% = 0.09\%$, if I assume equal probabilities to acquire disability each year within this age group. As a result, an individual has the probability of $\epsilon = 0.09\% \times 15 = 1.35\%$ to incur disability in period 2, and the expected incurring age is $45 + \frac{15}{2} = 52.5$.

The discussion above allows me to calculate the realized disposable income in period 2 if an individual with $LE \geq 60$ incurs disability with the probability of $\epsilon = 1.35\%$, which equals $g_2 = 7.5\mu_{2a} + 7.5(\mu_{2a} - \sigma_{2a}) = 15\mu_{2a} - 7.5\sigma_{2a}$. This also indicates that expected income shock in period 2 is $\sigma_2 = 7.5\sigma_{2a}$. On the other hand, the individual with $45 \leq LE < 60$ has $\sigma_2 = 0.5(LE - 45)\sigma_{2a}$, and $g_2 = (LE - 45)\mu_{2a} - 0.5(LE - 45)\sigma_{2a}$. And the individual with $LE < 45$ has no period 2, indicating that $\sigma_2 = 0$ and $g_2 = 0$. On the contrary, the disposable income in period 2 if an individual does not incur disability with the probability of $1 - \epsilon = 98.65\%$ is $g_2 = \mu_2$. Finally, the disability indicator, denoted by DI, follows a Bernoulli distribution which takes the value 1 (indicating the individual incurs disability) with probability 0.0135, i.e., $DI \sim Bernoulli(0.0135)$.

5.1.8 Initial Cash on Hand: I_1

I simplify the conceptual model by combing the initial wealth (w_0) and disposable income (g_1) in period 1, and defining it as cash on hand in period 1, i.e., I_1. However, individuals at age 16 in rural China are not able to collect any wealth by themselves before entering the workforce, and the main source of financial support for them is parental transfer which is already included in the calculation of disposable income (accounting for 21.5% of the disposable income on average). On the contrary, finance income, which is not included in disposable income, only accounts for a very small portion of disposable income in rural China. For instance, the average proportion of finance income is around 2.4% in 2020. This allows for my model simplification that $I_1 = g_1$, i.e., there is no initial wealth.

The remaining task is to find the distribution of g_1. According to CFPS 2016 rural survey data, the average individual (net) income by different age groups in 2015 is shown in Table 5.3. I can then estimate the average income values for period 1 and 2, which are 27,578.42 and 28,758.34 yuan, respectively.

It is consistent with the reality that, for the same individual, income in period 1 is positively correlated with that in period 2. To generate g_1 for simulation, I need to further assume that g_1 is proportional to μ_2, i.e., the expected disposable income in period 2. Under this assumption, I obtain $g_1 = \frac{27{,}578.42}{28{,}758.34} \times \frac{T_1}{T_2} \times \mu_2 = 1.85\mu_2 = 27.75\mu_{2a}$ for the individual with $LE \geq 60$. This result, i.e., $g_1 = 27.75\mu_{2a}$, can also be applied to the individual with $45 \leq LE < 60$ since she survives the entire period 1. As for the individual with $LE < 45$, we have $g_1 = \frac{LE-16}{T_1} \times 27.75\mu_{2a} = 0.96(LE - 16)\mu_{2a}$.

Table 5.3: Average Individual Net Income by Age in Rural China in 2015

Age Group	Average Income (Yuan)	Number of Individuals
15-19	20,585.42	106
20-24	25,638.98	384
25-29	30,530.54	608
30-34	32,453.55	310
35-39	32,166.11	225
40-44	27,864.90	225
45-49	27,451.81	211
50-54	24,355.19	208
55-59	23,508.79	99

5.2 Simulation Model

The simulation model structures a synthetic Chinese village that consists of 1,000 rural residents with life expectancy no less than 16. A resident i is characterized by discount parameters, denoted by β_i and β_i^{θ}, life expectancy at 16, denoted by LE_i, initial cash on hand, denoted by $I_{1,i}$, expected disposable income in period 2, denoted by $\mu_{2,i}$, income shock in period 2, denoted by $\sigma_{2,i}$, and disability indicator, denoted by DI_i. Since the discount parameters are solely dependant on one-year discount rate $d_i^{one\ year}$, and income-related variables, i.e., $\mu_{2,i}$, $\sigma_{2,i}$, and $I_{1,i}$, can all be calculated by annual income $\mu_{2a,i}$ and LE_i, we know that resident i is actually characterized by the quadruple $\{d_i^{one\ year}, LE_i, \mu_{2a,i}, DI_i\}$. Then I draw the characteristics of 1,000 residents from the distributions of $d^{one\ year}$, LE, μ_{2a}, and DI, as discussed in Section 5.1.

In period 1, each resident i, knowing her NRSPI participation decision, needs to decide savings $s_{1,i}$ and consumption $c_{1,i}$. In period 2, she must make decisions on savings $s_{2,i}$, NRSPI contribution $p_{2,i}$ and consumption $c_{2,i}$ after the disposable income $g_{2,i}$ is revealed. In period 3, she consumes $c_{3,i}$.

An NRSPI policy j consists of monthly basic pension payment, denoted by k_j, minimum total contribution, denoted by M_j, specified life span after 60, denoted by T_j, and long-term normalized savings rates, denoted by r_1 and r_2. Based on Section 5.1.4, r_1 and r_2 are determined by annual normalized savings rate, $r^{one\ year}$. Hence, policy j is characterized by the quadruple $\{k_j, M_j, T_j, r_j^{one\ year}\}$. I can repeat the simulation for the same population by changing the characterizations of the policy, given alternative values of policy parameters as discussed in Section 5.1.

5.3 Simulation Results

I start the simulation by drawing the population of 1,000 rural residents. To characterize the population, I draw LE from the distribution $GB2(20.80, 95.70, 0.1785, 3.10)$, draw $d^{one\ year}$ from the distribution $U(1.5\%, 10.3\%)$, draw μ_{2a} from the distribution $GB2(0.56, 4.18 \times 10^9, 6.90, 7,326.44)$, and draw DI from the distribution $B(1, 1.35\%)$, according to Section 5.1. The statistics for these four basic characteristics are presented in Table 5.4. All the means are similar with the real data, indicating the good quality of the simulated data.

Table 5.4: Means of Simulated Basic Individual Characteristics and Comparisons with the Real Data

Characteristic	Simulated Mean	Actual Mean
$d^{one\ year}$	0.060	0.059
LE	71.06	71.30
μ_{2a}	16,997.90	16,712.70
DI	0.013	0.0135

Based on different values of LE, there are three types of residents who have heterogeneous optimization problems. Among the 1,000 residents, 77 have life expectancy less than 45, 159 have life expectancy between 45 and 60, and 764 have life expectancy exceeding 60. Grouped means for the extended individual characteristics calculated based on the four basic characteristics are shown in Table 5.5. I make adjustments on the individuals with life expectancy less than 45, as well as between 45 and 60, according to the methods described in Section 5.1.7.

Table 5.5: Means of Extended Individual Characteristics by Life Expectancy Groups

Characteristic	$LE < 45$	$45 \leq LE < 60$	$LE \geq 60$
β	0.40	0.40	0.39
β^θ	0.55	0.55	0.55
I_1	285,253.7	456,054.7	476,703.9
μ_2	-	136,914.7	257,677.8
σ_2	-	33,883.4	63,847.6
g_2	-	136,260.4	256,999.8

The next step is to characterize the policy. Different from individual parameters, policy parameters are not randomly drawn. I simulate the process for the government to choose different policy characteristics. Specifically, I choose k from $\{55, 72, \ldots, 293, 310\}$, choose M from $\{1,500, 3,000, 4,500\}$, choose T from $\{99, 119, 139, 159, 179\}$, and choose $r^{one\ year}$ from $\{1.5\%, 2.0\%, 2.5\%, 3.0\%, 3.5\%\}$. Among these parameters, we need to pay attention to government-specified life span after 60, i.e., T. Although subject to changes, T is uniform across the country and has not changed since NRSPI was created. Local governments are not allowed to adjust the specified life span in practice. In addition, we need to keep in mind that NRSPI interest rate always has the opposite effect to $r^{one\ year}$. Compared to T and $r^{one\ year}$, k and M change more frequently and have larger variations across provinces.

5.3.1 Participation Rates

With all the parameters, I am able to explore participation rates following the rules discussed in the conceptual framework. Life expectancy is key to individuals' participation decisions, and policy characteristics affect the overall participation rates. It is redundant to present the results under each set of policy parameters, for which reason I first fix T and $r^{one\ year}$, and change the values of k and M. Specifically, I choose the current value of T, i.e., 139, and set $r^{one\ year}$ at the lowest value, i.e., 1.5%. The corresponding long-term normalized savings rates are $r_1 = 26.00\%$, and $r_2 = 12.88\%$.

I define the NRSPI participation rate under policy j as $rate_j$, which equals the number of

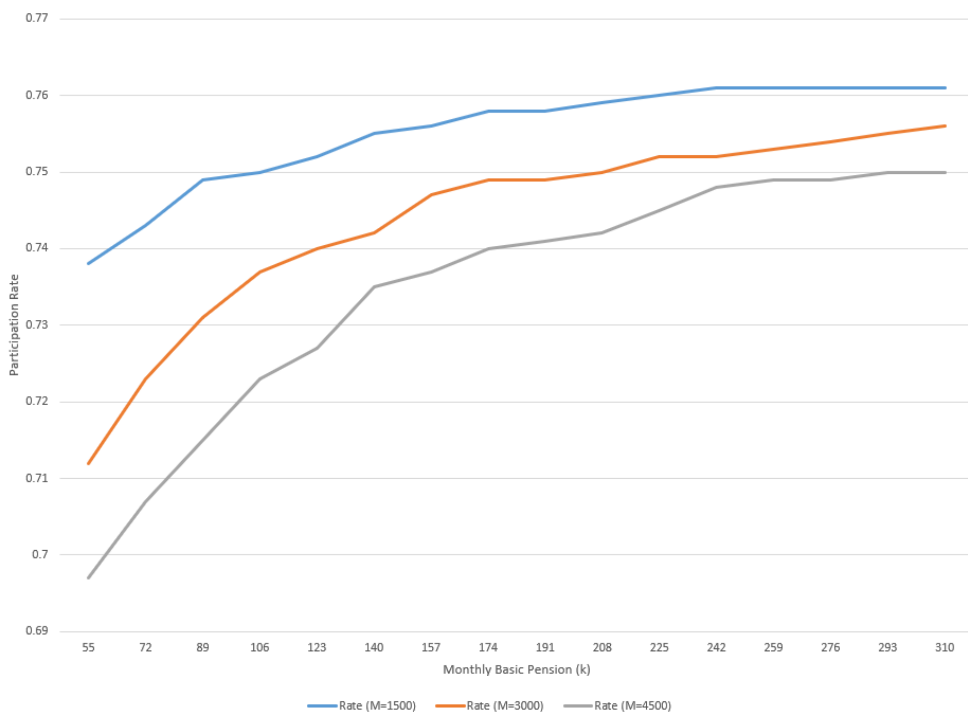
NRSPI participants (including those participate at and beyond the minimum contribution) over the population, i.e., $rate_j = \frac{Number\ of\ Participants}{1{,}000}$. The values of $rate_j$ under different k_j and M_j are reported in Table 5.6, and Figure 5.7 presents the relationship between $rate_j$ and k_j or M_j in a more straightforward way. To help better understand the results, I calculate the proportion of residents with life expectancy less than 60, which equals 23.6%. Due to the assumption of the conceptual model that individuals know their life expectancy, these residents will never participate in NRSPI no matter how policy characterizations change. Henceforth, I define them as non-participants. Once I exclude these non-participants, the lowest participation rate in Table 5.6 is 91.2%.

Table 5.6: NRSPI Participation Rates under Different Policy Characterizations ($T = 139$ and $r^{one\ year} = 1.5\%$)

Characteristic	$M = 1,500$	$M = 3,000$	$M = 4,500$
$k = 55$	0.738	0.712	0.697
$k = 72$	0.743	0.723	0.707
$k = 89$	0.749	0.731	0.715
$k = 106$	0.750	0.737	0.723
$k = 123$	0.752	0.740	0.727
$k = 140$	0.755	0.742	0.735
$k = 157$	0.756	0.747	0.737
$k = 174$	0.758	0.749	0.740
$k = 191$	0.758	0.749	0.741
$k = 208$	0.759	0.750	0.742
$k = 225$	0.760	0.752	0.745
$k = 242$	0.761	0.752	0.748
$k = 259$	0.761	0.753	0.749
$k = 276$	0.761	0.754	0.749
$k = 293$	0.761	0.755	0.750
$k = 310$	0.761	0.756	0.750

As we can observe, the NRSPI participation rate increases with monthly basic pension payment and decreases with minimum contribution, indicating that $\frac{\partial rate_j}{\partial k_j} > 0$ and $\frac{\partial rate_j}{\partial M_j} < 0$. The government can therefore stimulate participation by both increasing monthly basic pension payment and reducing minimum contribution. In addition, the marginal increase of

Figure 5.7: Changes in NRSPI Participation Rates as k Increases under Different Values of M ($T = 139$ and $r^{one\ year} = 1.5\%$)



$rate_j$ in k_j becomes larger as M_j increases, and the marginal decrease of $rate_j$ in M_j becomes smaller as k_j increases, confirming that mixed partial derivatives $\frac{\partial^2 rate_j}{\partial k_j \partial M_j} = \frac{\partial^2 rate_j}{\partial M_j \partial k_j} > 0$. Although not always the case, $\frac{\partial^2 rate_j}{\partial {k_j}^2}$ tends to be negative in general.

I verify my observations by calculating the elasticities of the NRSPI participation rate with respect to k and M in Table 5.7 and Table 5.8. Considering the fact that k and M are discrete with fairly large increments, I utilize the formula for the arc elasticity instead of the point elasticity, which is $e_j = \frac{rate_{j+1} - rate_j}{(rate_{j+1} + rate_j)/2} / \frac{Q_{j+1} - Q_j}{(Q_{j+1} + Q_j)/2}$, where Q can be k or M. Several conclusions can be drawn from the tables. First, elasticities with respect to k are non-negative and those with respect to M are all negative. Second, at the same level of k that is not too high, elasticities with respect to k have positive correlations with M. In the meantime, elasticities with respect to M at $M = 1,500$ are decreasing in k (in terms of absolute values). Third, the two elasticities are both small in magnitude, indicating that NRSPI participation is inelastic when the government makes adjustments on k and M. Such inelasticity is more evident when k is high and M is low.

Table 5.7: Elasticities of the NRSPI Participation Rate with Respect to k under Different Values of M ($T = 139$ and $r^{one\ year} = 1.5\%$)

Characteristic	$M = 1,500$	$M = 3,000$	$M = 4,500$
$k = 55$	0.0252	0.0573	0.0532
$k = 72$	0.0381	0.0521	0.0533
$k = 89$	0.0077	0.0469	0.0638
$k = 106$	0.0179	0.0274	0.0372
$k = 123$	0.0308	0.0209	0.0847
$k = 140$	0.0116	0.0587	0.0237
$k = 157$	0.0257	0.0260	0.0395
$k = 174$	0	0	0.0145
$k = 191$	0.0155	0.0157	0.0158
$k = 208$	0.0167	0.0337	0.0514
$k = 225$	0.0181	0	0.0552
$k = 242$	0	0.0196	0.0197
$k = 259$	0	0.0209	0
$k = 276$	0	0.0222	0.0223
$k = 293$	0	0.0235	0

Table 5.8: Elasticities of the NRSPI Participation Rate with Respect to M under Different Values of k ($T = 139$ and $r^{one\ year} = 1.5\%$)

Characteristic	$M = 1,500$	$M = 3,000$
$k = 55$	-0.0538	-0.0532
$k = 72$	-0.0409	-0.0559
$k = 89$	-0.0365	-0.0553
$k = 106$	-0.0262	-0.0479
$k = 123$	-0.0241	-0.0443
$k = 140$	-0.0261	-0.0237
$k = 157$	-0.0180	-0.0337
$k = 174$	-0.0179	-0.0302
$k = 191$	-0.0179	-0.0268
$k = 208$	-0.0179	-0.0268
$k = 225$	-0.0159	-0.0234
$k = 242$	-0.0178	-0.0133
$k = 259$	-0.0159	-0.0133
$k = 276$	-0.0139	-0.0166
$k = 293$	-0.0119	-0.0166
$k = 310$	-0.0099	-0.0199

I want to emphasize two substantial facts that lead to the inelastic participation rates.

First, since I keep T and $r^{one\ year}$ constant, parameters b and r_2 do not change, and the proportion of residents contributing beyond the minimum actually stays constant, which equals 53.4%. It means that the switch of participation decisions only happens between not participating and participating at minimum contribution. Second, as I have calculated, once I exclude the non-participants and focus on the possible participants, the lowest conditional participation rate (when $k = 55$ and $M = 4,500$) is already very high, which equals 91.2%. The highest conditional participation rate (when $k = 310$ and $M = 1,500$) reaches 99.6%, which is close to 100%. Thus, the increase in the participation rate is limited because of the extremely high initial participation rate. I further argue that the main cause of such high participation rate is the low level of minimum contribution, M. In Table 5.5, I show the average disposable income in period 2 is $g_2 = 256,999.8$ yuan, and the highest level of minimum contribution I choose is only $4,500$ yuan. Accounting for at most 1.8% of the income, M is too low to prevent most residents from participating. To test this hypothesis, I choose a much higher level of M, which equals $30,000$ yuan, and calculate the participation rates under different values of k while $T = 139$ and $r^{one\ year} = 1.5\%$. Table 5.9 presents the results. Under the same k, the participation rate is much lower. The lowest and highest participation rates are 59.1% and 68.8%, or equivalently 77.4% and 90.1% if I consider only possible participants. The change in the participation rate is evidently larger when M is set to be larger, confirming my argument.

Table 5.9: NRSPI Participation Rates under Different Monthly Basic Pension Benefits k When $M = 30,000$ ($T = 139$ and $r^{one\ year} = 1.5\%$)

k	Participation Rate	k	Participation Rate
55	0.591	191	0.660
72	0.606	208	0.663
89	0.616	225	0.668
106	0.624	242	0.673
123	0.634	259	0.677
140	0.639	276	0.680
157	0.643	293	0.684
174	0.650	310	0.688

Table 5.10: NRSPI Participation Rates under Different Policy Characterizations ($k = 55$ and $M = 1,500$)

Characteristic	$T = 99$	$T = 119$	$T = 139$	$T = 159$	$T = 179$
$r^{one\ year} = 1.5\%$	0.740	0.739	0.738	0.737	0.737
$r^{one\ year} = 2.0\%$	0.739	0.737	0.737	0.736	0.736
$r^{one\ year} = 2.5\%$	0.737	0.736	0.736	0.735	0.735
$r^{one\ year} = 3.0\%$	0.736	0.735	0.735	0.734	0.731
$r^{one\ year} = 3.5\%$	0.735	0.735	0.731	0.731	0.729

I am also interested in the effects of potential changes in T and $r^{one\ year}$, though in reality these changes are less likely to occur. To avoid redundant presentation and allow for comparisons, I set $k = 55$ and $M = 1,500$, which are both the minimum standards suggested by the central government. The values of $rate_j$ under different T_j and $r_j^{one\ year}$ are shown in Table 5.10. Consistent with the conceptual framework, the NRSPI participation rate decreases with the specified life span and interest rate. However, changes brought by T and $r^{one\ year}$ are much smaller, compared with those brought by k and M. On the one hand, decreasing T by 80 months merely increases $rate_j$ by 0.002 (when $r^{one\ year} = 2.5\%$) to 0.006 (when $r^{one\ year} = 3.5\%$). Thus, the government cannot effectively encourage participation by lowering T. This also provides theoretical support for the government's decision about sticking to a uniform specified life span. On the other hand, $rate_j$ only increases by 0.004 (when $T = 119$) to 0.008 (when $T = 179$) if $r^{one\ year}$ decreases from 3.5% to 1.5%. Therefore, the government is not able to rely on higher NRSPI interest rates (corresponding to lower values of $r^{one\ year}$) to promote NRSPI participation. Elasticities of the participation rate with respect to T and $r^{one\ year}$ are far more inelastic, whose absolute values are mostly lower than 0.008. For this reason, I do not present these elasticities in tables.

Contrary to the case where k and M change, the proportion of residents who contribute beyond the minimum is influenced by the values of T and $r^{one\ year}$. Table 5.11 presents the proportions under different T_j and $r_j^{one\ year}$, and Figure 5.8 graphically illustrates how this proportion changes with T_j and $r_j^{one\ year}$. It is interesting to note that, compared with their effects on the participation rate, the effects of T and $r^{one\ year}$ on the proportion of contributing beyond the minimum are significantly larger. Increasing T by 80 months decreases this proportion by 0.174 (when $r^{one\ year} = 1.5\%$) to 0.220 (when $r^{one\ year} = 3.5\%$), which means the government can effectively enhance the average contribution level by lowering the specified life span. Meanwhile, if $r_j^{one\ year}$ increases from 1.5% to 3.5%, the proportion of contributing beyond the minimum is reduced by 0.039 (when $T = 99$) to 0.085 (when $T = 179$). Therefore, NRSPI interest rate, opposite to $r^{one\ year}$, is positively related with the average contribution level.

Table 5.11: Proportions of Residents Contributing beyond the Minimum under Different Policy Characterizations ($k = 55$ and $M = 1,500$)

Characteristic	$T = 99$	$T = 119$	$T = 139$	$T = 159$	$T = 179$
$r^{one\ year} = 1.5\%$	0.615	0.573	0.534	0.483	0.441
$r^{one\ year} = 2.0\%$	0.608	0.566	0.526	0.472	0.426
$r^{one\ year} = 2.5\%$	0.600	0.549	0.505	0.459	0.404
$r^{one\ year} = 3.0\%$	0.588	0.542	0.489	0.440	0.386
$r^{one\ year} = 3.5\%$	0.576	0.533	0.474	0.420	0.356

Figure 5.8: Changes in Proportions of Residents Contributing beyond the Minimum as $r^{one\ year}$ Increases under Different Values of T ($k = 55$ and $M = 1,500$)

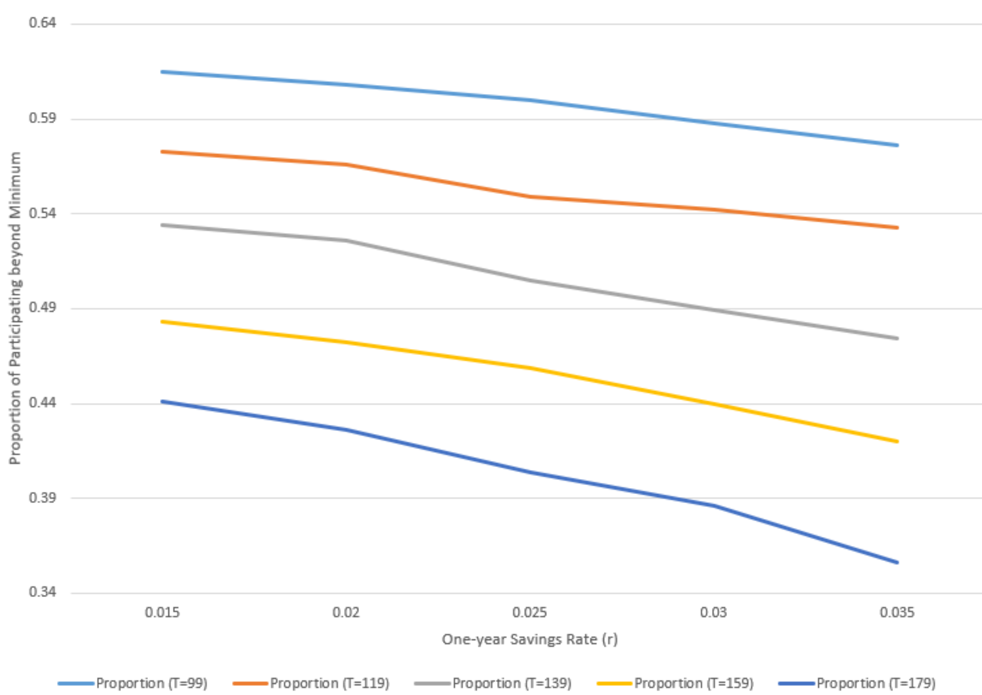


Table 5.12: Elasticities of the Proportion of Residents Contributing beyond the Minimum with Respect to T under Different Values of $r^{one\ year}$ ($k = 55$ and $M = 1,500$)

Characteristic	$T = 99$	$T = 119$	$T = 139$	$T = 159$
$r^{one\ year} = 1.5\%$	-0.385	-0.454	-0.747	-0.768
$r^{one\ year} = 2.0\%$	-0.390	-0.473	-0.806	-0.866
$r^{one\ year} = 2.5\%$	-0.484	-0.539	-0.711	-1.077
$r^{one\ year} = 3.0\%$	-0.444	-0.663	-0.786	-1.105
$r^{one\ year} = 3.5\%$	-0.423	-0.756	-0.900	-1.394

Moreover, I calculate the elasticities of proportion of contributing beyond the minimum with respect to T in Table 5.12. All the elasticities are negative, and their absolute values are large, indicating the proportion of contributing beyond the minimum is elastic when T changes. At the same level of T, the absolute values of elasticities are, in general, increasing in $r^{one\ year}$.

Table 5.13: Elasticities of the Proportion of Residents Contributing beyond the Minimum with Respect to $r^{one\ year}$ under Different Values of T ($k = 55$ and $M = 1,500$)

Characteristic	$T = 99$	$T = 119$	$T = 139$	$T = 159$	$T = 179$
$r^{one\ year} = 1.5\%$	-0.040	-0.043	-0.052	-0.081	-0.121
$r^{one\ year} = 2.0\%$	-0.060	-0.137	-0.183	-0.126	-0.239
$r^{one\ year} = 2.5\%$	-0.111	-0.071	-0.177	-0.232	-0.251
$r^{one\ year} = 3.0\%$	-0.134	-0.109	-0.202	-0.302	-0.526

Following the same logic, I calculate the elasticities of proportion of contributing beyond the minimum with respect to $r^{one\ year}$. Table 5.13 presents the results. Again, all the elasticities are negative, whose absolute values are relatively smaller than the case of T. Hence, T tends to has a greater impact on the proportion than $r^{one\ year}$ in this regard. In addition, the absolute values of elasticities at the same level of $r^{one\ year}$ are generally increasing in T.

Since k and M, as I have argued, have no effect on such proportion once T and $r^{one\ year}$ stay constant, I can conclude that T and $r^{one\ year}$ tend to affect participation decisions in a different way from k and M. Specifically, T and $r^{one\ year}$ mainly influence the proportion of contributing beyond the minimum (and therefore the average contribution level), while k and

M have much larger effects on the entire participation rate. In terms of policy implementations, the Chinese government should be aware that changing different policy characteristics have heterogeneous effects on participation decisions. Choosing the appropriate parameters is crucial to achieve policy objectives.

5.3.2 Simulated and Actual Participation Rates

It is worth noting that I am estimating the optimal participation decisions based on assumptions made in the conceptual framework. According to CFPS survey data, which document individual participation decisions across the country, the overall NRSPI participation rate for rural residents between 45 and 60 was 7.37% in 2010, 49.96% in 2012, 62.53% in 2014, and 62.27% in 2016.[5] While the extremely low participation rate in 2010 mainly results from limited access to NRSPI in many villages when the program was initially rolled out, the rates in other years are still lower than the simulated results in Table 5.6 (around 10% for 2014 and 2016).

Besides the impact of assuming no uncertainty in life expectancy, the gap between predicted and actual participation rates is likely due to the fact that some rural residents have not behaved optimally regarding NRSPI participation. Some residents may lack knowledge and information on NRSPI and are not able to discern fully its beneficial impacts (e.g., Hao and Jia, 2011; Wang, Zhou, and Zhu, 2013; Chang et al., 2014; Li and Cui, 2014; Liu and Xu, 2014). Further, some residents may lack trust in the government, not believing that the program is sustainable and capable of providing them benefits in the future (e.g., Mu and Yan, 2012; Ma, 2016; Ding et al., 2019; Wu, Zhang, and Lin, 2021).

Another potential reason for low actual participation rates is that some rural residents participate in other pension programs instead of NRSPI, but in my model I assume NRSPI is the only pension program available. For instance, 3.39% of rural residents participated in UESPI in 2016 since they were hired in the formal non-agricultural sector. In addition, 5.50% of rural residents had not switched from ORSPI to NRSPI by the end of 2016. Once

[5] I have not obtained access to more recent waves of CFPS data.

I exclude these residents, the participation rates were 52.40%, 69.53% , and 69.71% in 2012, 2014, and 2016, respectively. These revised participation rates in 2014 and 2016 are close to the simulated rates.

Despite the difference between the actual participation rate and the simulated rate, the simulation comparative statics still provide a valuable tool to understand how individual and policy parameters can affect participation. The government can benefit from the simulation results in deciding the direction of policy adjustments.

5.3.3 Optimal Values

I carry on by calculating the optimal values. Consistent with the conceptual framework, we have five different groups of residents. Residents in Group 1 to 3 have $LE > 60$, among whom Group 1 residents do not participate in NRSPI, Group 2 residents participate at the minimum contribution, and Group 3 residents participate beyond the minimum contribution. Besides, I also consider those with life expectancy between 45 and 60 (Group 4) and with life expectancy less than 45 (Group 5). Since the residents in Group 5 do not live to period 2, and those in Group 4 simply consume whatever they have in period 2 and do not live to period 3, I only calculate optimal values in period 1 for Group 5, and optimal values in period 1 and 2 for Group 4. Choosing $k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$ as the baseline policy characteristics, I obtain the average optimal savings, consumption, and contribution in the three periods for each group of residents in Table 5.14.

We should keep in mind that it is not of great interest to compare the optimal values among different groups due to several reasons. First, residents in Group 4 and 5 not only have different individual characteristics such as LE, I_1, and g_2, but also behave heterogeneously. Residents in Group 1, 2, and 3 have different optimal participation decisions when NRSPI is available. Thus, Group 1 residents choose to not participate in NRSPI because it maximizes their utilities, which is different from the case where there is no NRSPI in place. Comparing Group 1 with Group 2 and 3 provides us with little information about the impacts of NRSPI. Second, although all the individual parameters are randomly drawn, their sample means inevitably vary across groups, especially when it comes to income-related parameters whose standard deviations are very large. For example, the means of I_1 in Group 1, 2, and 3 are 503,227.3, 504,703.9, and 464,715.9 yuan, respectively.[6] As a result, optimal values in these groups are no longer comparable. Third, the existence of corner solutions for s_1 (i.e., $s_1 = 0$ due to $-B_i + \sqrt{\Delta_i} < 0$, which is discussed in Section 4.3.1.4) in Group 1 to 4 also makes comparisons less informative. Under the baseline policy characteristics, 9, 48, 166, and 33 residents in Group 1, 2, 3, and 4 have corner solutions $s_1 = 0$. I exclude these residents and show the optimal values for the remaining residents in Group 1 to 4 in Table 5.15. Compared with Table 5.14, the means of s_1, s_2, p_2, c_2, and c_3 generally increase, while the means of c_1 decrease. Changes in Group 1 are the most drastic due to its small group size, which implies the average optimal values in this group should not be used for comparisons. Hence, I would like to exclude Group 1 in the following discussion about optimal values.

Table 5.14: Means of Optimal Values by Groups of Residents ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$)

Group	1	2	3	4	5
Life Expectancy	$LE \geq 60$			$45 \leq LE < 60$	$LE < 45$
Participation	No	At M	Beyond M	No	No
Group Size	26	204	534	159	77
s_1	68,566.0	51,786.0	49,018.4	51,504.6	0
c_1	434,661.2	452,917.9	415,697.5	404,550.1	285,253.7
s_2	132,687.4	116,540.6	0	0	-
p_2	0	1,500.0	107,130.4	0	-
c_2	225,717.4	219,505.7	205,054.9	201,153.9	-
c_3	149,780.8	137,832.4	231,663.7	-	-

Based on this discussion, the small group size may lead residents in Group 1, 2, and 3 to differ significantly in terms of individual characteristics. I further verify my argument by choosing a much larger sample size, for instance, 100,000, and conducting the simulation again. Group sizes for Group 1, 2, and 3 become 3,139, 21,276, and 52,864, respectively.

[6] The mean for Group 1 is accidentally close to that for Group 2 because of the initial number I specify for random draws in Stata, which is also known as "seed". Once another initial number is chosen, the mean for Group 1 is no longer close to the others.

The means of I_1 in these groups are 481,438.1, 481,959.7, and 483,227 yuan, which are close to each other. I also summarize the means of optimal values for the three groups in Table 5.16. As we can see, optimal values for Group 1 change greatly, whose means are now more comparable with the other groups.

Table 5.15: Means of Optimal Values Excluding Residents with $s_1 = 0$ ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$)

Group	1	2	3	4
Group Size	17	156	368	126
s_1	104,865.7	67,720.1	71,130.0	64,993.9
c_1	430,159.0	435,675.0	403,904.2	391,392.2
s_2	165,521.1	128,855.5	0	0
p_2	0	1,500.0	126,146.0	0
c_2	255,807.5	226,654.7	219,662.8	199,206.6
c_3	186,844.3	151,712.5	270,035.4	-

Table 5.16: Means of Optimal Values for Residents in Group 1, 2, and 3 When Sample Size is 100,000 ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$)

Group	1	2	3
Participation	No	At Minimum	Beyond Minimum
Group Size	3,139	21,276	52,864
s_1	56,024.5	55,178.5	54,313.4
c_1	425,413.6	426,781.2	428,913.6
s_2	119,518.3	115,217.9	0
p_2	0	1,500.0	114,401.1
c_2	210,315.8	212,362.5	214,388.4
c_3	134,915.2	136,379.0	245,147.0

However, I want to make it clear that the following discussion about the policy effectiveness and efficiency is not affected even if the means of optimal values in the three groups are different, for which reason I continue to set the sample size as 1,000.

I can explore how the average optimal values in each group change as one of the policy parameters changes. Let us start by discussing k. As k increases, some residents in Group 1 will switch to Group 2. In fact, 23 out of 26 residents switch from Group 1 to Group 2 when

k increases from 55 to 310 ($M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$). Once I exclude these switchers, I am able to analyze comparative statics for those who remain in the same group. As I have argued, I do not consider Group 1, and focus on Group 2 and 3. The average optimal values for the residents who always stay in Group 2 and 3 under different k are displayed in Table 5.17. In period 1, s_1 decreases and c_1 increases with k in both groups. In period 2, c_2 increases with k in both groups, s_2 decreases for Group 1, and p_2 decreases for Group 3. In period 3, c_3 is also increasing with k in the two groups. Therefore, consistent with the results of comparative statics in the conceptual framework, I show that optimal values of consumption in all the three periods are positively correlated with monthly basic pension benefits, and optimal values of savings and NRSPI contribution (specific to Group 3 in period 2) are decreasing with k. The income effect of NRSPI dominates, as participants save or contribute less in exchange for more consumption in young age, expecting more NRSPI benefits in the future.

Table 5.17: Means of Optimal Values for Residents Staying in Group 2 and 3 under Different k ($M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$)

k	55	140	225	310
Group 2				
s_1	51,786.0	49,252.4	46,938.0	44,784.8
c_1	452,917.9	455,451.5	457,765.9	459,919.1
s_2	116,540.6	110,717.8	104,983.8	99,315.7
p_2	1,500.0	1,500.0	1,500.0	1,500.0
c_2	219,505.7	222,136.4	224,954.3	227,909.5
c_3	137,832.4	139,371.0	141,009.9	142,723.1
Group 3				
s_1	49,018.4	45,365.5	42,065.0	39,112.2
c_1	415,697.5	419,350.5	422,650.9	425,603.7
s_2	0	0	0	0
p_2	107,130.4	97,733.1	88,481.5	79,378.6
c_2	205,054.9	209,849.7	214,942.9	220,325.3
c_3	231,663.7	236,493.0	241,605.0	247,025.3

I next consider M. If M increases while other characteristics stay the same ($k = 55$, $T = 139$, and $r^{one\ year} = 1.5\%$), residents in Group 2 might switch to Group 1. I find 41 out of 204 residents join Group 1 from Group 2 when M increases from 1,500 to 4,500, who need to be excluded. Since optimal values in Group 3 are not related with M at all, I only present the average optimal values for the residents who always stay in Group 2 under different M in Table 5.18. Again, I obtain the similar conclusions as the conceptual framework. Savings in period 1 will increase, while savings in period 2, as well as all the consumption, will decrease as minimum contribution requirement gradually increases. The financial responsibility in period 2 due to higher contribution requirement forces participants to consume less before, during, and after this period. However, the changes in optimal values are relatively small compared with those in Table 5.17. It is mainly because of the low level of M in comparison to the average individual income, as I have argued in Section 5.3.1. The range of M I choose, i.e., 3,000 yuan, is still too small to deliver a significant impact on optimal behaviors.

Table 5.18: Means of Optimal Values for Residents Staying in Group 2 under Different M ($k = 55$, $T = 139$, and $r^{one\ year} = 1.5\%$)

M	1,500	3,000	4,500
s_1	49,182.8	49,350.0	49,517.6
c_1	455,274.9	455,107.7	454,940.1
s_2	114,088.5	112,961.2	111,833.9
p_2	1,500.0	3,000.0	4,500.0
c_2	218,415.4	218,253.5	218,091.9
c_3	135,965.2	135,870.1	135,775.3

As for the effect of changing T, I find that 174 out of 615 residents leave Group 3 to join Group 2, and 3 residents initially in Group 2 switch to Group 1 when T increases from 99 to 179 ($k = 55$, $M = 1,500$, and $r^{one\ year} = 1.5\%$).[7] Excluding these individuals, I show the average optimal values for those who stick to Group 2 or Group 3 under different T in Table 5.19. The changes in Group 2 and 3 go in the opposite direction. Values of Savings all increase with T, and values of consumption all decrease with T in Group 2, though the changes are relatively small. Group 2 residents account somewhat for the lower attractiveness

[7]It also means the group size of Group 1 increases by 3.

Table 5.19: Means of Optimal Values for Residents Staying in Group 2 and 3 under Different T ($k = 55$, $M = 1,500$, and $r^{one\ year} = 1.5\%$)

T	99	139	179
Group 2			
s_1	47,709.6	47,805.0	47,858.0
c_1	437,483.5	437,388.1	437,335.1
s_2	110,730.5	110,950.7	111,072.6
p_2	1,500.0	1,500.0	1,500.0
c_2	209,287.6	209,187.6	209,132.5
c_3	129,937.4	129,878.8	129,846.6
Group 3			
s_1	49,211.1	48,489.5	47,776.4
c_1	419,037.2	419,758.8	420,471.9
s_2	0	0	0
p_2	108,995.8	107,229.0	105,465.7
c_2	205,178.4	206,036.1	206,901.0
c_3	348,160.1	248,905.0	194,014.3

of NRSPI as T increases by increasing savings in periods 1 and 2.

For Group 3, however, savings in period 1, contribution in period 2, and consumption in period 3 all decrease with T, but values of consumption in period 1 and 2 increase with T. Hence, the impact brought by increasing specified life span is more complicated for Group 3 since the decrease in monthly NRSPI benefits is positively correlated with the level of contribution. Group 3 residents invest less in NRSPI, i.e., p_2 is decreasing in T, as the program becomes less attractive and, accordingly, save less in period 1 to fund period 2 investment and consume more in both periods 1 and 2. The last parameter to discuss is $r^{one\ year}$, which is positively correlated with r_1 and r_2. When $r^{one\ year}$ increases from 1.5% to 3.5% ($k = 55$, $M = 1,500$, and $T = 139$), 60 out of 534 residents go from Group 3 to Group 2, and 7 out of 204 residents who are initially in Group 2 switch to Group 1. I then display the average optimal values for those who remain in Group 2 and 3 all the time under different $r^{one\ year}$ in Table 5.20. It is evident that the values of savings and contribution (in Group 3) are increasing with $r^{one\ year}$. The values of consumption in period 1 decrease with $r^{one\ year}$, but the values in period 2 and 3 are increasing with $r^{one\ year}$. Group 2 and

3 residents utilize the high normalized savings rates (corresponding to low NRSPI interest rates) in period 1 to save more money, which they then use to increase both consumption and NRSPI contribution in period 2. Thus, I attain the somewhat surprising result that less attractive NRSPI interest rates actually increase NRSPI contributions for Group 3 members.

Table 5.20: Means of Optimal Values for Residents Staying in Group 2 and 3 under Different $r^{one\ year}$ ($k = 55$, $M = 1,500$, and $T = 139$)

$r^{one\ year}$	1.5%	2.5%	3.5%
Group 2			
s_1	52,341.2	69,365.6	87,385.8
c_1	458,034.1	441,009.7	422,989.5
s_2	117,783.4	131,540.2	149,729.5
p_2	1,500.0	1,500.0	1,500.0
c_2	222,009.9	244,925.2	276,657.6
c_3	139,391.4	167,617.2	205,784.8
Group 3			
s_1	50,283.4	64,914.2	81,289.9
c_1	420,976.7	406,345.9	389,970.1
s_2	0	0	0
p_2	109,099.3	121,285.4	137,890.1
c_2	208,119.3	228,612.7	257,874.1
c_3	245,431.0	270,990.0	305,881.5

All the simulation results confirm my findings in the conceptual framework. Higher one-year normalized savings rate leads to higher long-term normalized savings rates in both periods, which in turn enhance the saving incentives for the residents. More savings in period 1 also renders contribution and consumption in the following periods to increase.

Using the optimal values, I can also calculate the average ratios of savings and consumption in period 1 for the residents in Group 1 to 3 under different values of k and M ($T = 139$ and $r^{one\ year} = 1.5\%$), which are shown in Table 5.21. Consistent with the previous analysis, I still focus on the residents who do not change participation decisions. As we can see, savings and consumption in Group 1 are not correlated with k and M, therefore stay unchanged in the four cases. For Group 3, only k negatively affects the ratio. As for Group 2, the ratio decreases with k and increases with M. What is more, under the same k and M, I find the ratio is decreasing from Group 1 to Group 3. It indicates that the savings/consumption ratio in period 1 decreases with residents' contribution to NRSPI. Residents are likely to save a smaller share of initial cash on hand for the future once they expect to participate in NRSPI and receive benefits. NRSPI serves as a replacement for the traditional savings vehicle by providing a higher unit profit for the participants.

Table 5.21: Average Savings/Consumption Ratio in Period 1 by Groups under Different k and M ($T = 139$ and $r^{one\ year} = 1.5\%$)

Group	1	2	3
$k = 55$ and $M = 1,500$	0.2591	0.1409	0.1287
$k = 55$ and $M = 4,500$	0.2591	0.1425	0.1287
$k = 310$ and $M = 1,500$	0.2591	0.1100	0.0887
$k = 310$ and $M = 4,500$	0.2591	0.1111	0.0887

Finally I examine the crowding out and poverty-alleviating effects of NRSPI. What are the optimal savings and consumption for NRSPI participants (i.e., Group 2 and 3) if there is no NRSPI in place? How large are the impacts of NRSPI? To answer these questions, I need to calculate the optimal values without NRSPI in period 1 and 2 for the participants. I am more interested in how the crowding out effects vary under different k and M, so I set $T = 139$ and $r^{one\ year} = 1.5\%$. This time I do not need to exclude switchers since I do not compare optimal values under different policy characteristics. For each combination of k and M, the differences and percentage changes of optimal values in Group 2 and 3 with and without NRSPI (for instance, $\Delta s_1 = s_1^{NRSPI} - s_1^{No\ NRSPI}$, and the percentage change equals $\frac{\Delta s_1}{s_1^{No\ NRSPI}}$) are shown in Table 5.22. As we can observe, NRSPI implementation leads participants to save less even before they actually start contributing. Correspondingly, they consume more in both periods. As a result, individual utilities for Group 2 and 3 increase, confirming that NRSPI alleviates poverty for the participants by providing secure income in the future. The existence of basic pension, a social pension component providing transfers to eligible participants, facilitates the reduction of poverty. The same conclusion is also obtained in He and Li (2020). Huang and Zhang (2021) do not find any evidence that

NRSPI implementation enhances consumption, but it may result from the fact that they focus on all the residents between 45 and 60 rather than the participants. Increasing the minimum contribution does not affect Group 3 and only has a small impact on Group 2. On the contrary, raising k significantly enlarges the differences. This is consistent with previous findings that policy adjustments on k are more effective than M. In addition, differences in Group 3 tend to be larger than differences in Group 2.

To quantitatively evaluate the crowding out effect, I focus on Δs_2 and Δp_2. Under each combination of k and M, the absolute value of Δs_2 is larger than Δp_2 for both groups. Thus, the decrease in savings is larger than the increase in NRSPI contribution. If I define the crowding out rate as $CO = \frac{|\Delta s_2|}{\Delta p_2}$, its value is always larger than 1. NRSPI contribution reduces savings in a fashion that the sum of them also decrease, indicating that participants react to the implementation of NRSPI by switching out of savings to meet the contribution requirement and in the meanwhile improve consumption. Such effect is more evident in Group 3, where contribution fully crowds out savings and makes participants enjoy a higher consumption, compared with the no NRSPI case. These findings are consistent with the work of Chetty et al. (2014), which emphasizes voluntary pension schemes do not effectively enhance total savings (including private savings and pension contributions). In terms of poverty alleviation, the existence of NRSPI helps reduce poverty by allowing participants to spend more money.

5.3.4 Net Government Expenditures

Now I turn my focus to the government's expenditure on NRSPI, which is of great importance but yet less-studied. For each participant i, the government receives total NRSPI contributions $p_{2,i}$, which is defined as government revenue, and pays both basic and individual account pension benefits $b_i(a_i + p_{2,i})$, which is defined as government expenditure. For non-participants, there is no revenue or expenditure. By choosing different policy characterizations, government revenue, denoted by rev, and government expenditure, denoted by

Table 5.22: Differences and Percentage Changes of Average Optimal Values for NRSPI Participants with and without NRSPI Policy under Different k and M ($T = 139$ and $r^{one\ year} = 1.5\%$)

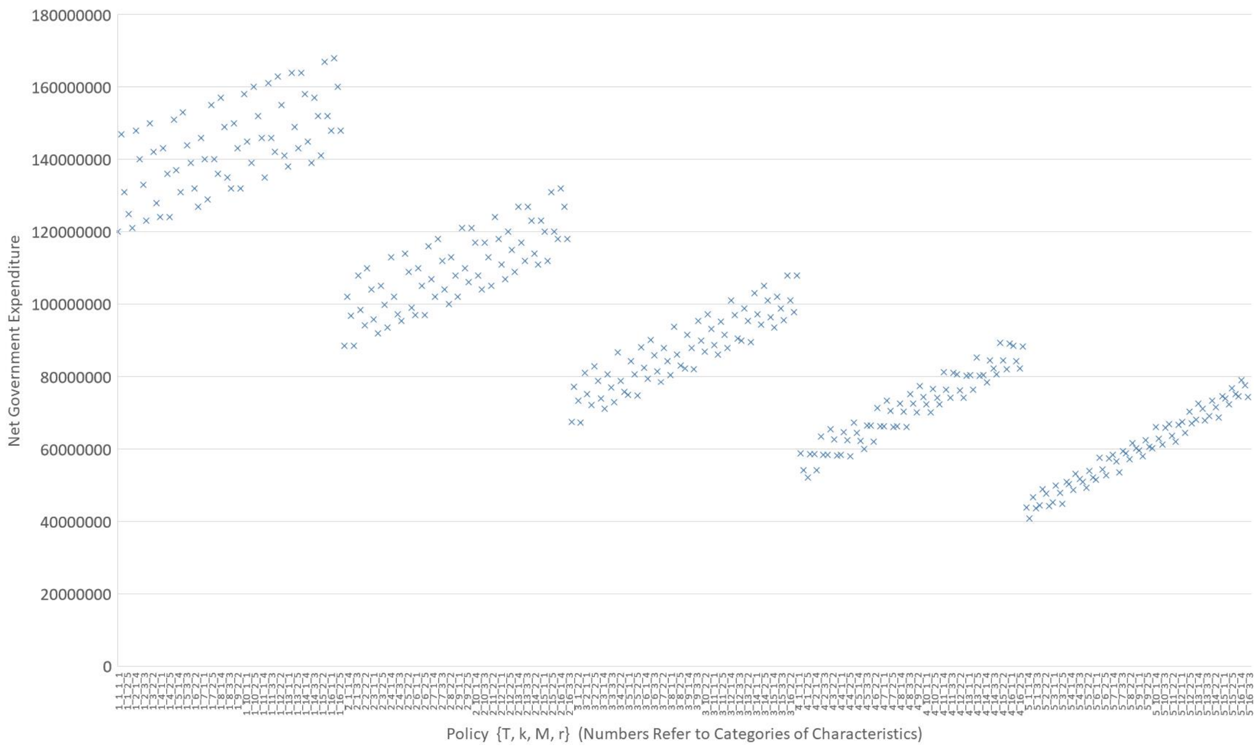
	$k=55$, $M=1500$	$k=55$, $M=4500$	$k=310$, $M=1500$	$k=310$, $M=4500$
Group 2				
Δs_1	-1,486.4 (-10.23%)	-1,441.4 (-9.25%)	-7,713.0 (-36.17%)	-7,700.8 (-35.74%)
Δc_1	1,486.4 (0.54%)	1,441.4 (0.49%)	7,713.0 (2.80%)	7,700.8 (2.75%)
Δs_2	-4,132.9 (-5.92%)	-7,058.2 (-9.84%)	-16,616.8 (-25.10%)	-19,524.3 (-29.33%)
Δp_2	1,500.0 (-)	4,500.0 (-)	1,500.0 (-)	4,500.0 (-)
Δc_2	760.1 (0.60%)	742.1 (0.58%)	5,398.8 (4.55%)	5,321.6 (4.49%)
Group 3				
Δs_1	-2,536.4 (-17.48%)	-2,536.4 (-17.48%)	-12,442.6 (-52.61%)	-12,442.6 (-52.61%)
Δc_1	2,536.4 (0.98%)	2,536.4 (0.98%)	12,442.6 (4.60%)	12,442.6 (4.60%)
Δs_2	-112,108.1 (-)	-112,108.1 (-)	-107,434.6 (-)	-107,434.6 (-)
Δp_2	107,130.4 (-)	107,130.4 (-)	79,378.6 (-)	79,378.6 (-)
Δc_2	1,782.0 (1.82%)	1,782.0 (1.82%)	12,378.9 (12.70%)	12,378.9 (12.70%)

exp, will both change accordingly. Defining net government expenditure under policy j as $netexp_j = exp_j - rev_j$, I am able to calculate $16 \times 3 \times 5 \times 5 = 1200$ values of $netexp_j$ under different policy characterizations.

Figure 5.9 exhibits the scatter plot of the computed net government expenditures, where each point in the horizontal axis represents one policy characterization. All the net expenditures are positive, indicating that NRSPI is always beneficial to residents at the cost of government. I then utilize Figure 5.10 to analyze the effects of policy parameters on net government expenditure. In each of the four components in Figure 5.10, I let one parameter change while fixing the other three to evaluate how net government expenditure change accordingly. It is evident that net expenditure is decreasing in M and T, but increasing in k and $r^{one\ year}$.

Based on my argument, net government expenditure reaches minimum $(40,660,588)$ when $k = 55$, $M = 4,500$, $T = 179$, and $r^{one\ year} = 1.5\%$, and touches maximum $(168,445,061)$ when $k = 310$, $M = 1,500$, $T = 99$, and $r^{one\ year} = 3.5\%$. Besides, I also calculate the arc elasticities of net government expenditure with respect to each parameter when the other three parameters are fixed. Figure 5.11 displays their values and trends, each of whose com-

Figure 5.9: Net Government Expenditures under Different Policy Characterizations



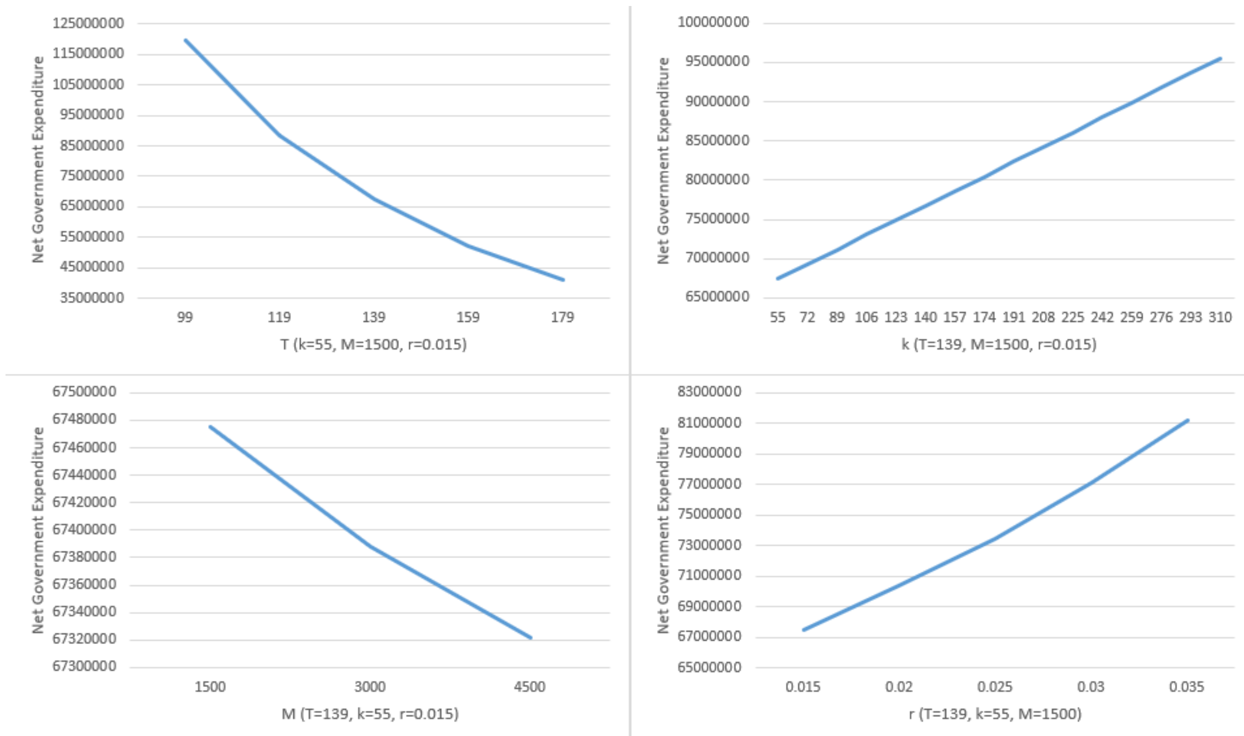
ponents corresponds to one parameter. I learn from the figure that elasticities with respect to M and T are negative, and elasticities with respect to k and $r^{one\ year}$ are positive. In each case, absolute values of elasticities increase with the parameter. What is more, net government expenditure is the most elastic with respect to T, and the most inelastic with respect to M. Elasticities with respect to the other two parameters lie in between.

Table 5.23: Comparisons between the NRSPI Participation Rate and Net Government Expenditure in Terms of the Effects of Parameters

	NRSPI Participation Rate		Net Government Expenditure	
Parameter	Sign	Magnitude	Sign	Magnitude
k	+	Large	+	Medium
M	-	Large	-	Small
T	-	Small	-	Large
$r^{one\ year}$	-	Small	+	Medium

Let us assume that the government seeks to achieve the objectives of enhancing the

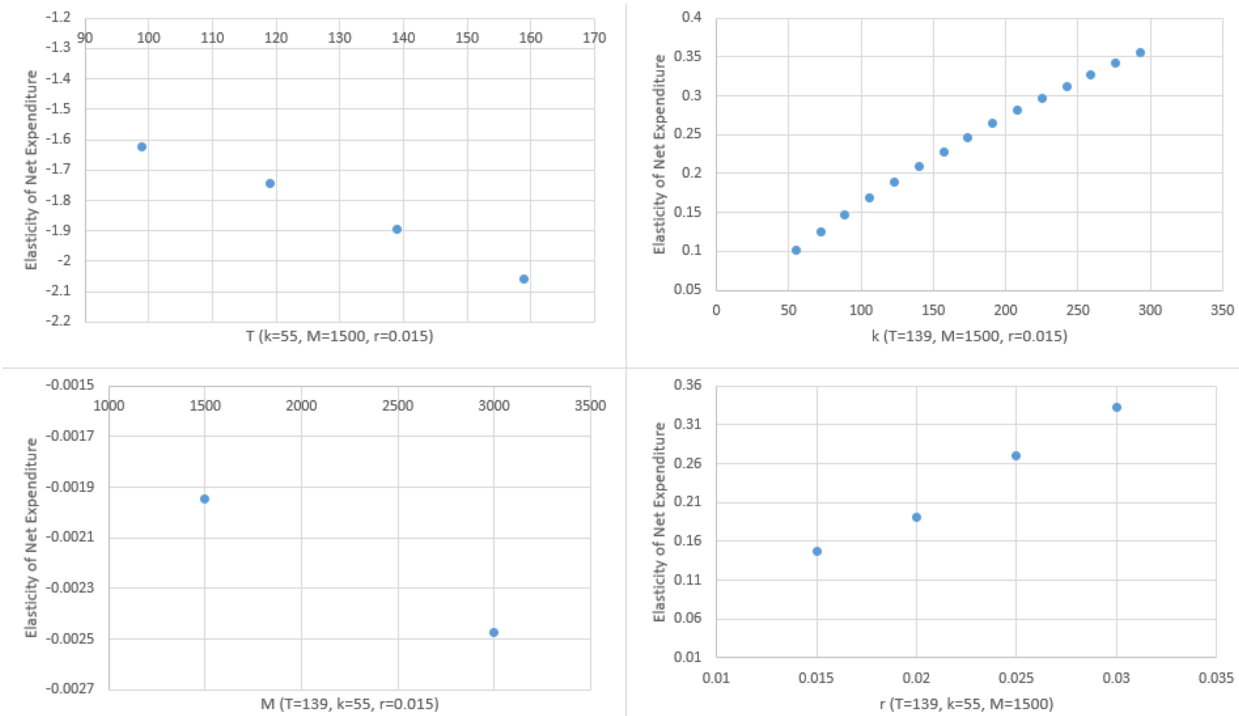
Figure 5.10: Net Government Expenditures When One Parameter Changes



participation rate and reducing net government expenditure. I have shown that, similar with the net government expenditure, the participation rate is also increasing in k, and decreasing in M and T. Nevertheless, the increase in $r^{one\ year}$ tends to have opposite effects on the participation rate and net expenditure. While the participation rate is mainly affected by k and M, net government expenditure changes more substantially with k and T. I roughly report the qualitative comparisons between them in Table 5.23, from which I am able to draw some interesting conclusions. First, the government prefers lower level of M since increasing M greatly reduces the participation rate but just cuts net expenditure by a very small amount. Second, the government prefers higher level of T since increasing T only leads to a small reduction in the participation rate, but reduces a large amount of net expenditure. Third, the government wants $r^{one\ year}$ to be low, since it not only enhances the participation rate, but also reduces net expenditure.

I go on to explore the trade-off between the two objectives by graphing Figure 5.12, which

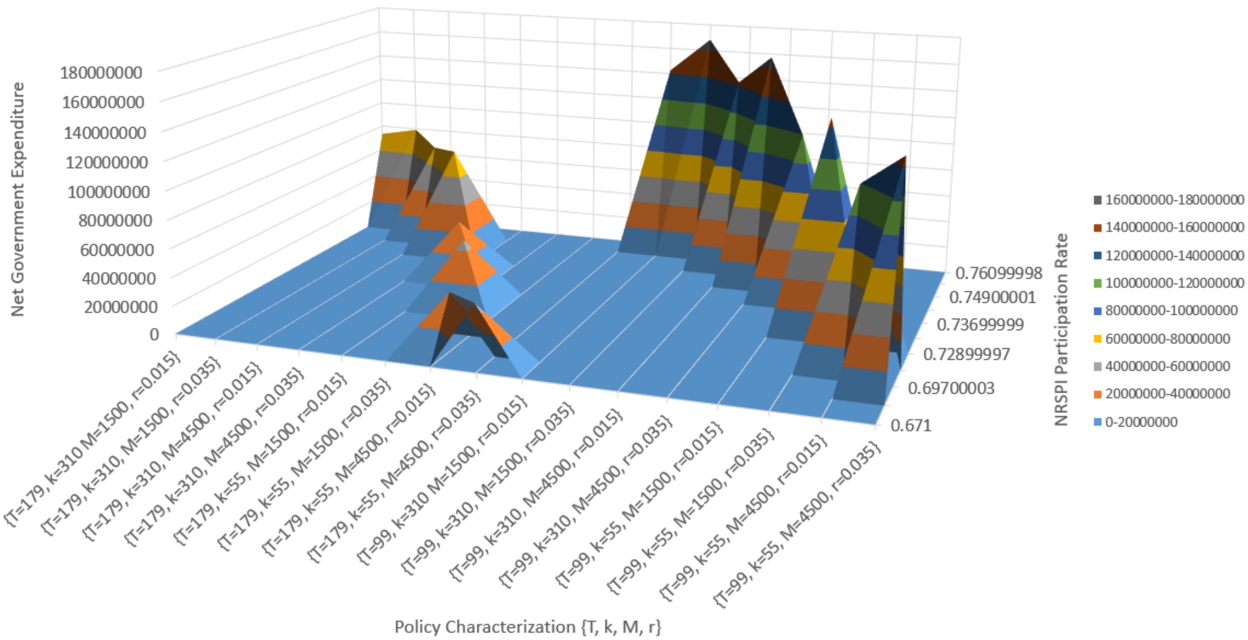
Figure 5.11: Elasticities of Net Government Expenditure with Respect to One of the Policy Parameters When the Other Parameters Are Fixed



shows how the participation rate and net government expenditure change under different policy characterizations. For each parameter, I only choose their minimum and maximum values to keep the figure clean and avoid redundant comparisons. As we can observe, net expenditure is positively correlated with the participation rate in general. The combination of low net expenditure and high participation rate is more likely to occur when T is larger, indicating $T = 179$ is preferable. Fixing T at 179, the effects of increasing k on both the NRSPI participation rate and net expenditure are considerably large. On the contrary, M mainly affects the participation rate, and $r^{one\ year}$ only significantly influences net expenditure. Moreover, proportional changes in net expenditure are relatively larger than those in the participation rate.

To be more rigorous, I need to verify my observations about Figure 5.12. Hence, I calculate the ratio of net government expenditure and percent of the participation rate, which is denoted by unp, i.e., unit net expenditure. Thus, under policy j, we have $unp_j = \frac{netexp_j}{100 \times rate_j}$.

Figure 5.12: Trade-Offs between Government Expenditures and NRSPI Participation Rates

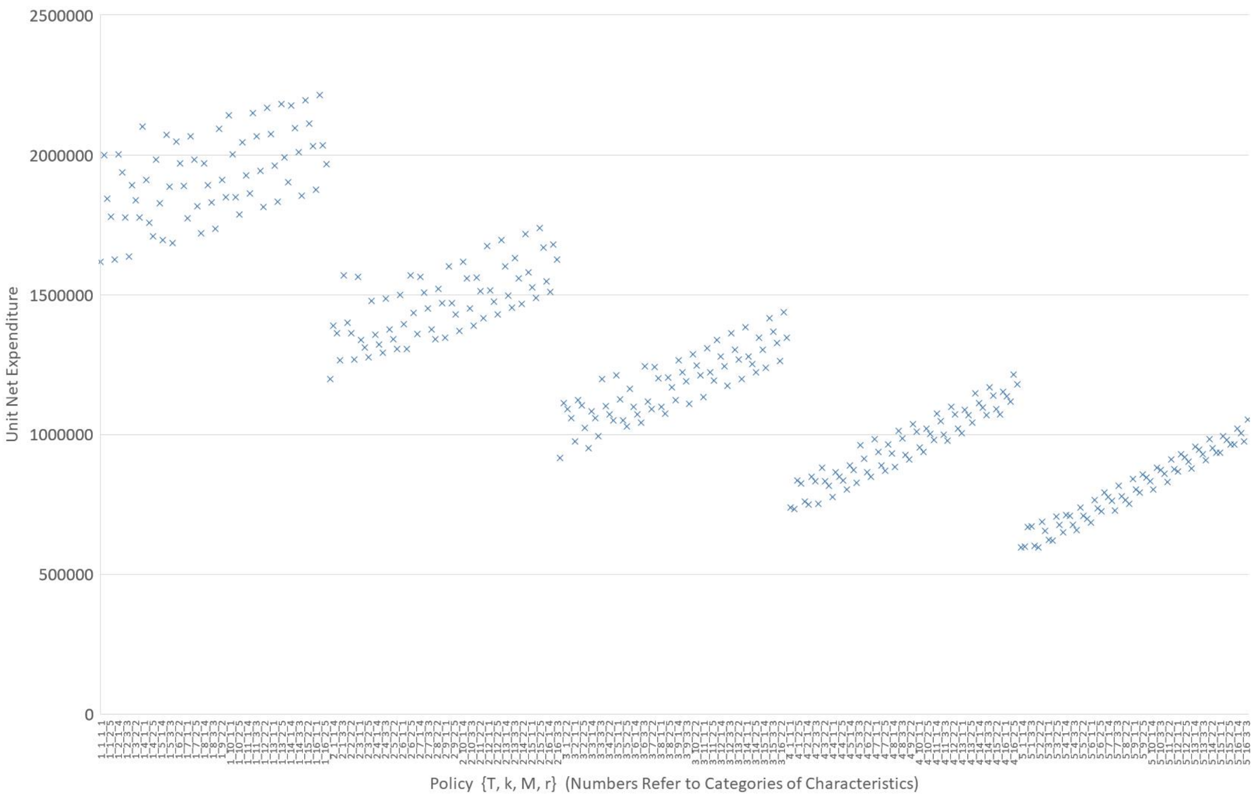


Lower level of unp indicates the policy is more efficient in achieving both objectives. The calculated unit net expenditures under different policy characterizations are displayed in Figure 5.13. The pattern of changes in the figure suggests that unp is decreasing in T, but increasing in k, M, and $r^{one\ year}$.

Sorting the values of unp_j, I find that unit net expenditure is the smallest when $k = 55$, $M = 1,500$, $T = 179$, and $r^{one\ year} = 1.5\%$. The corresponding net government expenditure and participation rate are 40,897,400 and 0.737, respectively. This participation rate is adequately high, representing a conditional participation rate of 96.5% for possible participants. I therefore conclude that the government needs to choose small values of k, M, and $r^{one\ year}$, and a large value of T, if it aims to efficiently promote participation while maintaining a relatively low net expenditure.

Based on the discussion, it seems that the government can make the NRSPI interest rate as high as possible (even higher than the long-term market savings rate) since it reduces net expenditure and enhances the participation rate. However, we need to be aware that I am calculating total government expenditure and revenue on the 1,000 simulated rural

Figure 5.13: Unit Net Expenditures under Different Policy Characterizations



residents throughout their lifetime. In reality, government revenue occurs in period 2, and government expenditure occurs in period 3. A high NRSPI interest rate motivates more residents to participate at a higher average contribution level, but forces the government to pay much more in the future. Considering the fact that NRSPI contributions are not specifically kept for repaying the participants, the government needs to budget for a larger future expenditure the higher the interest rate assigned to NRSPI contributions. Moreover, a growing proportion of rural seniors puts even heavier pressure on the government budget.

Recalling the definition of government expenditure, exp, I can break it down it into two portions, namely basic pension payment and individual account payment. In Table 5.24 I report the proportions of basic pension payment in government expenditure under different policy characterizations. From the table, we know proportions vary from 0.062 to 0.713. I draw four conclusions by comparing the proportions. First, monthly basic pension payment greatly impacts proportion, which is intuitive. Second, minimum total contribution does not significantly affect the proportion. Third, specified life span is positively correlated with the proportion since it lowers the individual account payment. Fourth, the proportion of basic pension payment is decreasing in annual normalized savings rate. A higher normalized savings rate, corresponding to a lower NRSPI interest rate, renders a part of participants to switch from contributing beyond the minimum to contributing at the minimum, which lowers their individual account benefits. However, according to Table 5.20, it leads to higher contributions, and consequently higher individual account benefits for those who continue to contribute beyond the minimum. The latter effect overshadows the former effect, resulting in a higher level of individual account payment. Since basic pension payment is nearly not affected, its proportion decreases.[8]

Table 5.24: Proportions of Basic Pension Payment in Government Expenditure under Different Policy Parameter Characterizations

Policy	Proportion of Basic Pension Payment
$k = 55, M = 1,500, T = 99, r^{one\ year} = 1.5\%$	0.077
$k = 55, M = 1,500, T = 99, r^{one\ year} = 3.5\%$	0.063
$k = 55, M = 4,500, T = 99, r^{one\ year} = 1.5\%$	0.077
$k = 55, M = 4,500, T = 99, r^{one\ year} = 3.5\%$	0.062
$k = 310, M = 1,500, T = 99, r^{one\ year} = 1.5\%$	0.367
$k = 310, M = 1,500, T = 99, r^{one\ year} = 3.5\%$	0.310
$k = 310, M = 4,500, T = 99, r^{one\ year} = 1.5\%$	0.367
$k = 310, M = 4,500, T = 99, r^{one\ year} = 3.5\%$	0.310
$k = 55, M = 1,500, T = 179, r^{one\ year} = 1.5\%$	0.226
$k = 55, M = 1,500, T = 179, r^{one\ year} = 3.5\%$	0.197
$k = 55, M = 4,500, T = 179, r^{one\ year} = 1.5\%$	0.225
$k = 55, M = 4,500, T = 179, r^{one\ year} = 3.5\%$	0.195
$k = 310, M = 1,500, T = 179, r^{one\ year} = 1.5\%$	0.713
$k = 310, M = 1,500, T = 179, r^{one\ year} = 3.5\%$	0.661
$k = 310, M = 4,500, T = 179, r^{one\ year} = 1.5\%$	0.716
$k = 310, M = 4,500, T = 179, r^{one\ year} = 3.5\%$	0.663

Now I do a counterfactual analysis by assuming there is no NRSPI and, instead the government provides a direct cash transfer to each resident, the amount of which equals

[8]Recall the fact that the NRSPI participation rate is very inelastic to normalized savings rate.

the present value in period 1 of net government expenditure on this resident under NRSPI. Thus, the counterfactual is designed so that the government is indifferent between offering NRSPI and offering a precise cash transfer that residents could use to save for old age. Since government revenue under NRSPI is received in period 2 and government expenditure occurs in period 3, the equation of the present value of net government expenditure on resident i under policy j is:

$$netexp_{i,j} = \frac{exp_{i,j}}{(1+r_1)(1+r_2)} - \frac{rev_{i,j}}{(1+r_1)}. \tag{5.13}$$

Table 5.25: Average Utilities of the NRSPI and Precise Cash Transfer Programs under Different Policy Parameter Characterizations

Policy	NRSPI	Cash Transfer	No Program
$k = 55, M = 1,500, T = 99, r^{one\ year} = 1.5\%$	20.285	20.361	20.102
$k = 55, M = 1,500, T = 99, r^{one\ year} = 3.5\%$	20.340	20.389	20.211
$k = 55, M = 4,500, T = 99, r^{one\ year} = 1.5\%$	20.265	20.346	20.095
$k = 55, M = 4,500, T = 99, r^{one\ year} = 3.5\%$	20.332	20.383	20.195
$k = 310, M = 1,500, T = 99, r^{one\ year} = 1.5\%$	20.335	20.418	20.113
$k = 310, M = 1,500, T = 99, r^{one\ year} = 3.5\%$	20.390	20.438	20.212
$k = 310, M = 4,500, T = 99, r^{one\ year} = 1.5\%$	20.346	20.430	20.121
$k = 310, M = 4,500, T = 99, r^{one\ year} = 3.5\%$	20.394	20.444	20.214
$k = 55, M = 1,500, T = 179, r^{one\ year} = 1.5\%$	20.193	20.206	20.119
$k = 55, M = 1,500, T = 179, r^{one\ year} = 3.5\%$	20.266	20.272	20.218
$k = 55, M = 4,500, T = 179, r^{one\ year} = 1.5\%$	20.174	20.189	20.097
$k = 55, M = 4,500, T = 179, r^{one\ year} = 3.5\%$	20.261	20.267	20.210
$k = 310, M = 1,500, T = 179, r^{one\ year} = 1.5\%$	20.282	20.306	20.112
$k = 310, M = 1,500, T = 179, r^{one\ year} = 3.5\%$	20.337	20.345	20.211
$k = 310, M = 4,500, T = 179, r^{one\ year} = 1.5\%$	20.292	20.316	20.121
$k = 310, M = 4,500, T = 179, r^{one\ year} = 3.5\%$	20.340	20.347	20.213

Based on equation (5.13), we know the amount of transfer is $trans_{i,j} = netexp_{i,j}$, and the initial cash on hand for resident i under policy j becomes $I_1 + trans_{i,j}$. Assuming other individual characteristics stay constant, I calculate the optimal values under the precise cash transfer program. Then I am able to calculate and compare the life-time utilities between the two programs. Results indicate that utilities under the precise cash transfer program are always larger than or equal to utilities under the NRSPI program, indicating individuals are better off if the government makes equivalent direct transfers in period 1 instead of providing pension benefits in period 3, and if individuals optimally allocate the transfer across the three periods of life.[9] I also report the average utilities of the two programs under different policy characterizations in Table 5.25.

In general, the differences of average utilities are small, especially when the values of T and $r^{one\ year}$ are high. It means the equivalent variation of the utility benefits from the NRSPI can be very close to the net government expenditure, suggesting that NRSPI is a relatively effective pension program in the sense that it does almost as well as the the cash transfer program. I verify this argument by showing in Table 5.25 that the average utilities when there is no program in place are significantly smaller than those under the NRSPI or cash transfer program.

In reality, however, the government cannot know ex ante what participation decision each resident is going to make and how much she will contribute. Therefore, the government may consider a universal cash transfer program providing the same amount of cash to each resident at the age of 16 in lieu of having NRSPI. The amount is equal to the present value of total net expenditure divided by 1,000. I calculate the utility of each resident under such universal cash transfer program, and compare it with the utility under NRSPI. Table 5.26 reports the differences of total utilities between the two programs, defined by $U^{NRSPI} - U^{Cash\ Transfer}$, for different groups of residents.[10]

According to Table 5.26, total utilities for Group 1 and 2 are always negative, indicating the universal cash transfer program makes residents not participating or contributing at the minimum better off. For Group 3, total utilities are negative when T is low, but turn positive when T is high. Residents contributing beyond the minimum prefer the universal

[9] This conclusion may not hold once I introduce uncertainty over life expectancy, where the government decides the amount of cash transfer according to the expected value of net expenditure. Then it is possible for a defined benefit pension scheme that provides guaranteed benefits in the future to deliver greater utility than its expected cash value.

[10] Note that I separate residents with different participation decisions under NRSPI to evaluate the heterogeneous effects of the two programs on different groups. Due to this reason, I do not present differences of average utilities since group sizes vary and group-level differences of average utilities cannot correctly reflect the impacts on the entire society.

cash transfer when policy-specified life span is low, and are better off under NRSPI when it is high. As for the entire population, total utilities are mostly negative, except the cases where k, T, and $r^{one\ year} = 3.5$ are all high. Hence, in most cases a universal cash transfer in period 1 delivers a higher utility to the population than the NRSPI program if each resident optimally allocates the transfer.

Table 5.26: Differences of Total Utilities between the NRSPI and Universal Cash Transfer Programs for Residents with Different Participation Decisions under Different Policy Parameter Characterizations

Policy	Group 1	Group 2	Group 3
$k = 55, M = 1,500, T = 99, r^{one\ year} = 1.5\%$	-6.950	-34.585	-41.546
$k = 55, M = 1,500, T = 99, r^{one\ year} = 3.5\%$	-5.762	-32.258	-18.408
$k = 55, M = 4,500, T = 99, r^{one\ year} = 1.5\%$	-18.671	-23.186	-41.401
$k = 55, M = 4,500, T = 99, r^{one\ year} = 3.5\%$	-15.252	-23.047	-18.267
$k = 310, M = 1,500, T = 99, r^{one\ year} = 1.5\%$	-1.365	-41.956	-30.505
$k = 310, M = 1,500, T = 99, r^{one\ year} = 3.5\%$	-1.017	-38.167	-7.039
$k = 310, M = 4,500, T = 99, r^{one\ year} = 1.5\%$	-4.879	-38.997	-30.250
$k = 310, M = 4,500, T = 99, r^{one\ year} = 3.5\%$	-3.723	-35.980	-6.794
$k = 55, M = 1,500, T = 179, r^{one\ year} = 1.5\%$	-2.528	-23.363	10.111
$k = 55, M = 1,500, T = 179, r^{one\ year} = 3.5\%$	-1.930	-15.750	11.158
$k = 55, M = 4,500, T = 179, r^{one\ year} = 1.5\%$	-7.419	-19.097	10.463
$k = 55, M = 4,500, T = 179, r^{one\ year} = 3.5\%$	-5.921	-12.293	11.452
$k = 310, M = 1,500, T = 179, r^{one\ year} = 1.5\%$	-0.744	-29.907	25.385
$k = 310, M = 1,500, T = 179, r^{one\ year} = 3.5\%$	-0.495	-19.118	24.792
$k = 310, M = 4,500, T = 179, r^{one\ year} = 1.5\%$	-2.662	-28.857	25.839
$k = 310, M = 4,500, T = 179, r^{one\ year} = 3.5\%$	-1.805	-18.583	25.174

Despite the fact that the precise cash transfer always outperforms NRSPI in theory, it is likely not a feasible alternative to NRSPI in reality. The reason is that some residents may not behave optimally and, instead, spend their transfer in periods 1 and 2, leaving them destitute entering old age in period 3 and still in need of a government pension program such as NRSPI.

5.3.5 Regional Heterogeneity

I continue the simulation by utilizing the real data and introducing regional heterogeneity. Examining the basic characteristics for residents in this simulation model, the two characteristics that play the major role in regional differences are life expectancy at 16, i.e., LE, and annual income, i.e., μ_{2a}. While μ_{2a} only influences optimal values, LE also affects participation decisions. Therefore, I am interested in how the heterogeneity in life expectancy across provinces results in different participation rates. On the other hand, among the policy characteristics, T is uniform across provinces, and the differences in M and $r^{one\ year}$ are relatively small. Only monthly basic pension payment, k, evinces a large variation. Hence, the regional heterogeneity in policy characteristics mainly comes from k. Therefore, I characterize a province z by its average life expectancy and monthly basic pension payment, i.e., $\{LE_z, k_z\}$.[11]

I collect province-level average life expectancy data from the Sixth National Population Census conducted in 2010. Recalling that the nationwide average life expectancy in 2010 is 74.9, I can calculate the ratios of regional life expectancy and national life expectancy. Then I multiply the estimated life expectancy in rural areas in 2010 (see Section 5.1.5) with these ratios to obtain the corresponding life expectancy estimates for all the provinces. Using the estimates, I fit the GB2 distribution for each province. The final step is to simulate 1,000 residents for each province and randomly draw their life expectancy values from the corresponding fitted distributions. Means of simulated life expectancy in the 31 provinces are shown in Table 5.27.

As for the monthly basic pension payment, I refer to the values in 2014 in Table 2.2. I do not use the values of k in the previous years because the variations of k are relatively small in these years mainly due to the new implementation of NRSPI. Local governments had not worked out the best plan to enhance monthly basic pension benefits on a regular basis before 2014.

Letting $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$, I calculate the participation rates and proportions to contribute beyond the minimum in all provinces, and present them in Table 5.27. From the table, I can learn that differences in regional participation rates are

[11] The variations in LE and k are usually much larger across provinces than within provinces, for which reason I focus on regional heterogeneity at province level.

large. While Beijing has a participation rate as high as 79.4%, Tibet sees its participation rate merely reach 60.8%. The regional differences in the proportions of contributing more than the minimum are even larger. The proportion in Beijing (59.3%) is over two times of the value in Tibet (28.1%).

Table 5.27: Proportions of Participation and Participation beyond the Minimum across Provinces ($M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$)

Province	LE	k	Participation Rate	Participation beyond Minimum
Beijing	73.88	430	0.794	0.593
Tianjin	71.34	227.5	0.762	0.534
Hebei	69.97	65	0.738	0.484
Shanxi	68.71	67.5	0.711	0.471
Neimenggu	69.34	67.5	0.739	0.480
Liaoning	70.87	62.5	0.738	0.533
Jilin	69.72	55	0.718	0.469
Heilongjiang	69.93	62.5	0.735	0.498
Shanghai	74.21	540	0.806	0.592
Jiangsu	70.88	97.5	0.758	0.520
Zhejiang	71.58	100	0.770	0.542
Anhui	70.02	62.5	0.747	0.507
Fujian	70.13	77.5	0.737	0.508
Jiangxi	68.32	62.5	0.693	0.466
Shandong	70.83	70	0.758	0.537
Henan	67.91	75	0.705	0.435
Hubei	69.70	62.5	0.718	0.494
Hunan	68.86	67.5	0.710	0.478
Guangdong	71.55	80	0.776	0.537
Guangxi	69.41	82.5	0.729	0.492
Hainan	70.62	127.5	0.761	0.525
Chongqing	70.90	87.5	0.755	0.533
Sichuan	69.82	67.5	0.727	0.502
Guizhou	65.26	62.5	0.648	0.360
Yunnan	63.76	67.5	0.619	0.288
Tibet	62.92	130	0.608	0.281
Shaanxi	68.91	67.5	0.725	0.460
Gansu	66.84	72.5	0.699	0.390
Qinghai	65.23	110	0.684	0.354
Ningxia	67.36	115	0.712	0.396
Xinjiang	67.18	107.5	0.707	0.428

It is also consistent with my previous findings that both proportions are increasing with LE and k. From Table 5.27, we know average LE, in general, has a positive correlation with k. It reflects the economic development levels and government financial conditions of different provinces. In theory, provinces with lower average life expectancy ought to set a higher level of k in order to achieve the same participation rate as others. In reality, however, local governments in these provinces can hardly meet the financial responsibility of increasing k. Such deviation between theory and reality is worth noting, and I suggest that the central government needs to consider subsidizing these provinces so that the local governments can enhance their basic pension payments and make NRSPI more attractive to rural residents. Otherwise, regional heterogeneity of NRSPI participation and benefits is likely to expand.

5.3.6 Government Subsidies

Now I evaluate the feasibility for the government to subsidize individual contribution. According to the rule of NRSPI introduced in Section 2.4, a government subsidy is proportional to individual contribution and serve as an addition to individual account balance. Thus, residents still need to meet the minimum contribution requirement since subsidies are directly deposited into their individual accounts after they contribute. Assuming the subsidy rate is q which falls between 0 and 1, cash on hand in period 3 becomes $(1 + r_2)s_2 + 1\{p_2 \geq M\}b[a + (1 + q)p_2]$. Participation decisions are affected by subsidies since contribution becomes more beneficial. To be specific, residents will not participate in NRSPI (belonging to Group 1) if $1+r_2 \geq b(1+q)$ and $(1+r_2)M \geq b[a+(1+q)M]$, will participate in NRSPI at minimum contribution (belonging to Group 2) if $1 + r_2 \geq b(1 + q)$ and $(1 + r_2)M \geq b[a + (1 + q)M]$, and will participate in NRSPI beyond minimum contribution (belonging to Group 3) if $1+r_2 < b(1+q)$. As long as $q > 0$, we know the proportion of Group 1 decreases and the proportion of Group 3 increases, indicating that both the participation rate and proportion to contribute beyond the minimum increase with q. Optimal values in Group 2 and 3 will also change with q correspondingly, but I do not need to calculate all of them since I only care about the participation rate and net government expenditure. For

Group 2, each participant still contribute M so no calculation for optimal values is needed. For Group 3, I need to calculate new optimal values of s_1 and $p_2$using the following equation:

$$s_1^* = \frac{-B_q + \sqrt{\Delta_q}}{2A_q}, \tag{5.14}$$

$$p_2^* = \frac{\beta^\theta (g_2 + (1 + r_1)s_1^*) - a}{1 + \beta^\theta + q}, \tag{5.15}$$

where $A_q = [\beta(1 + \beta^\theta + q) + 1](1 + r_1)^2$, $B_q = [\beta(1 + \beta^\theta + q) + 2](1 + r_1)Y - \beta(1 + \beta^\theta + q)(1 + r_1)^2 I_1 - [(1-\epsilon)\beta(1+\beta^\theta+q)+1](1+r_1)\sigma_2$, $C_q = Y(Y - \sigma_2) - \beta(1+\beta^\theta+q)(1+r_1)[Y-(1-\epsilon)\sigma_2]I_1$, and $\Delta_q = B_q^2 - 4A_qC_q$.

Table 5.28: NRSPI Participation Rates, Net Government Expenditures, and Unit Net Expenditures When k Increases ($T = 139$, $M = 1,500$ and $r^{one\ year} = 1.5\%$)

k	Participation Rate	Net Government Expenditure	Unit Net Expenditure
55	0.738	67,475,568	914,303
72	0.743	69,322,400	933,007
89	0.749	71,174,384	950,259
106	0.750	73,029,328	973,724
123	0.752	74,887,664	995,847
140	0.755	76,748,552	1,016,537
157	0.756	78,612,072	1,039,842
174	0.758	80,478,816	1,061,726
191	0.758	82,348,848	1,086,396
208	0.759	84,223,688	1,109,667
225	0.760	86,103,008	1,132,934
242	0.761	87,985,672	1,156,185
259	0.761	89,870,192	1,180,949
276	0.761	91,758,608	1,205,764
293	0.761	93,649,712	1,230,614
310	0.761	95,544,040	1,255,507

Among the policy parameters, the most flexible and effective one for the government to change is monthly basic pension payment if it wants to enhance the participation rate. What is more, k belongs to the social pension component of NRSPI and is fully subsidized by the government. From this perspective, basic pension payment can be regarded as another form of government subsidy. I am therefore interested in the comparisons of policy effectiveness between raising monthly basic pension payment and increasing subsidy rate. For simplicity, I continue to choose $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$. I summarize the participation rates, net government expenditures, and unit net expenditures when k increases from the baseline 55 yuan to 310 yuan in Table 5.28. Note that I assume $q = 0$ in this case, so the optimal values are the same as what I have shown in Section 5.3.3.

Table 5.29: NRSPI Participation Rates, Net Government Expenditures, and Unit Net Expenditures When q Increases ($T = 139$, $k = 55$, $M = 1,500$ and $r^{one\ year} = 1.5\%$)

q	Participation Rate	Net Government Expenditure	Unit Net Expenditure
0.1	0.739	76,602,048	1,036,564
0.2	0.739	86,637,921	1,172,367
0.3	0.740	96,557,716	1,304,834
0.4	0.740	106,182,452	1,434,898
0.5	0.740	115,492,466	1,560,709
0.6	0.740	124,500,338	1,682,437
0.7	0.740	133,074,792	1,798,308
0.8	0.741	141,440,523	1,908,779
0.9	0.741	149,559,290	2,018,344
1.0	0.741	157,253,316	2,123,177

Instead of increasing k, I fix k at the minimum level ($k = 55$) and choose different values of q to see how the participation rate, net government expenditure, and unit net expenditure change. Table 5.29 presents the results. This time, I need to recalculate optimal s_1 and p_2 values using equations (5.14) and (5.15). It is surprising that the participation rate has little reaction to the increasing subsidy rate, but net government expenditure exhibits a significantly positive correlation with subsidy rate, becoming twice as large when q increases from 0.1 to 1. I also calculate the proportion to contribute beyond minimum under different values of q, finding that the proportion increases from 0.557 to 0.666 as q increases from 0.1 to 1. Therefore, I conclude that a matching subsidy proportional to NRSPI contribution mainly enhances the average contribution level of participants, but has little effect on enhancing the participation rate. Besides, this type of subsidy is costly for the government. My findings confirm the empirical results from Lin and Zhang (2019), which also indicate that matching subsidies fail to enhance the NRSPI participation rate. Only incentive subsidies that provide extra rewards for the participants contributing for more than 15 years can promote the NRSPI participation rate effectively.

It is clear that raising monthly basic pension payment effectively improves the participation rate, but does not impact the proportion of residents who contribute beyond the minimum. On the contrary, increasing the subsidy rate to NRSPI contribution significantly enhances the average contribution level of participants, but almost has no effect in promoting the participation rate. The two methods serve for different policy objectives, and should not be considered as substitutes.

5.3.7 Maximum Contribution

I go on to examine the potential effects of introducing the maximum contribution level, which exists in reality but is not included in the conceptual framework. As I have argued, maximum contribution does not impact participation decisions. What is more, residents in Group 1 and 2 stay unaffected by the maximum contribution. As for residents in Group 3, those who initially contribute less than the maximum contribution level in period 2 are not affected. However, residents who would contribute more than the maximum contribution level are influenced, as they have to reduce contributions in period 2 to the maximum level. Whether they want to contribute in period 1 to make up for the reduction depends on the comparison between b and $(1+r_1)(1+r_2)$. If $b<(1+r_1)(1+r_2)$, they will not contribute in period 1. If $b>(1+r_1)(1+r_2)$, they will contribute a positive amount in period 1.

I report the number of Group 3 residents contributing below and above the maximum level under different policy characterizations in Table 5.30.[12] For the residents contributing above the minimum, I further divide them into two parts based on the values of b and $(1+r_1)(1+r_2)$. From Table 4.5, we can see the proportion of residents who contribute below the maximum level is positively correlated with k and negatively correlated with $r^{one\ year}$. It

[12]According to Table 4.5, M does not affect p_2^*, so I exclude M in this discussion.

means the impact of introducing the maximum level is smaller when monthly basic pension payment is high and annual normalized savings rate is low (i.e., NRSPI interest rate is high). In addition, the proportion of residents contributing in period 1 is decreasing in $r^{one\ year}$. An increase in $r^{one\ year}$ indicates a decrease in NRSPI interest rate, which in turn makes NRSPI less attractive. Consequently, residents constrained by the maximum contribution level in period 2 are less likely to contribute in period 1.

Table 5.30: Number of Group 3 Residents Contributing below and above the Maximum Contribution Level in Period 2 under Different Policy Parameter Characterizations

Policy	Below	Above & $b < (1+r_1)(1+r_2)$	Above & $b > (1+r_1)(1+r_2)$
$k = 55, T = 99, r^{one\ year} = 1.5\%$	62	45	508
$k = 55, T = 99, r^{one\ year} = 3.5\%$	37	182	357
$k = 310, T = 99, r^{one\ year} = 1.5\%$	162	39	414
$k = 310, T = 99, r^{one\ year} = 3.5\%$	115	157	304
$k = 55, T = 179, r^{one\ year} = 1.5\%$	61	114	266
$k = 55, T = 179, r^{one\ year} = 3.5\%$	28	312	16
$k = 310, T = 179, r^{one\ year} = 1.5\%$	177	77	187
$k = 310, T = 179, r^{one\ year} = 3.5\%$	115	227	14

5.3.8 Impacts of the Utility Dependent on Life Expectancy

Finally I explore the potential impacts on the simulation results if we adopt the assumption that the utility in period 3 depends on life expectancy. To start, I need to specify the functional form of $l(LE)$. Since the mean of LE for the residents with $LE \geq 60$ is 78.40, we can assume $l(LE)$ takes the following functional form:

$$l(LE) = \frac{1}{78.4 - 60}(LE - 60) = \frac{1}{18.4}(LE - 60). \tag{5.16}$$

Based on equation (5.16), the utility in period 3 is increasing in LE. Residents with $LE < 78.4$ have lower utilities with the same level of consumption in period 3 under the new assumption, while those with $LE > 78.4$ have higher utilities with the same level of consumption in period 3.

As I have pointed out, this assumption does not affect participation decisions. Therefore, all the simulation results related with participation rates are not affected, indicating that we can trust all the findings in Sections 5.3.1 and 5.3.5. In addition, the main conclusion about government subsidies in Section 5.3.6 is that a matching subsidy cannot effectively enhance the participation rate, which is still valid under the new assumption.

Contrary to participation decisions, optimal values are influenced by the assumption. Replacing β^θ with $\frac{1}{18.4}(LE-60)\beta^\theta$ in all equations of optimal values, we recalculate optimal values for residents with different participation decisions in Table 5.31 (corresponding to Table 5.14).

Table 5.31: Means of Optimal Values by Groups of Residents ($k = 55$, $M = 1,500$, $T = 139$, and $r^{one\ year} = 1.5\%$) If Utility in Period 3 Depends on Life Expectancy

Group	1	2	3	4	5
Life Expectancy	$LE \geq 60$			$45 \leq LE < 60$	$LE < 45$
Participation	No	At M	Beyond M	No	No
Group Size	26	204	534	159	77
s_1	21,025.5	26,470.1	60,446.8	51,504.6	0
c_1	482,201.8	478,233.7	404,269.1	404,550.1	285,253.7
s_2	11,300.29	54,112.39	0	0	-
p_2	0	1,500.0	130,160.9	0	-
c_2	287,205.6	250,037.1	196,423.6	201,153.9	-
c_3	12,756.04	67,361.87	292,694.2	-	-

Compared with Table 5.14, values for Group 1 to 3 are significantly different in Table 5.31. Residents in Group 1 and 2 have lower life expectancy, so they tend to save less and consume more in period 1 and 2. As a result they consume less in period 3. By contrast, residents in Group 3 have higher life expectancy which leads them to save or contribute more and consume less in period 1 and 2. Consequently they consume more in period 3.

Despite the changes in optimal values, the comparative statics of average optimal values when one policy parameter changes, as reported in Table 5.17 to Table 5.20, all stay the same qualitatively. What is more, I obtain similar conclusions when I compare the magnitudes of changes brought by different parameters in different groups.

The crowding out effect of NRSPI contributions is of great importance to study, so we present the differences and percentage changes of average optimal values for the participants with and without NRSPI in Table 5.32. All the qualitative results obtained from Table Table 5.22 are still valid in Table 5.32. Most importantly, we still find NRSPI contributions crowd out savings and enhance consumption for the participants, indicating that the poverty-alleviating effect of NRSPI also exists. Percentage changes of s_2 are much larger under the new assumption, and the differences of c_2 for Group 3 are now lower than those for Group 2. The main reason for these changes in magnitude is that the two groups have different means of LE. Residents in Group 2 have low life expectancy and tend to save less for period 3, while residents in Group 3 have high life expectancy and want to consume more in period 3.

Table 5.32: Differences and Percentage Changes of Average Optimal Values for NRSPI Participants with and without NRSPI Policy under Different k and M ($T = 139$ and $r^{one\ year} = 1.5\%$) If Utility in Period 3 Depends on Life Expectancy

	$k = 55$, $M = 1500$	$k = 55$, $M = 4500$	$k = 310$, $M = 1500$	$k = 310$, $M = 4500$
Group 2				
Δs_1	-1,154.8 (-14.55%)	-1,171.5 (-12.70%)	-5,726.6 (-46.31%)	-5,765.3 (-46.04%)
Δc_1	1,154.8 (0.73%)	1,171.5 (0.66%)	5,726.6 (3.78%)	5,765.3 (3.74%)
Δs_2	-4,670.5 (-12.43%)	-7,522.0 (-15.43%)	-19,930.6 (-60.81%)	-22,713.4 (-67.39%)
Δp_2	1,500.0 (-)	4,500.0 (-)	1,500.0 (-)	4,500.0 (-)
Δc_2	1,715.5 (0.44%)	1,546.0.1 (0.37%)	11,215.3 (4.32%)	10,949.4 (4.04%)
Group 3				
Δs_1	-2,794.1 (-18.99%)	-2,794.1 (-18.99%)	-13,621.3 (-51.02%)	-13,621.3 (-51.02%)
Δc_1	2,794.1 (1.34%)	2,794.1 (1.34%)	13,621.3 (6.24%)	13,621.3 (6.24%)
Δs_2	-134,774.2 (-)	-134,774.2 (-)	-129,003.9 (-)	-129,003.9 (-)
Δp_2	130,160.9 (-)	130,160.9 (-)	103,001.9 (-)	103,001.9 (-)
Δc_2	1,092.8 (0.23%)	1,092.8 (0.23%)	8,839.9 (5.28%)	8,839.9 (5.28%)

Now I look at net government expenditures. Recalling that government revenue stems from NRSPI contributions in period 2 and government expenditure comes from basic pension and individual account pension payments in period 3, we know the new assumption affects net government expenditure by increasing NRSPI contributions and individual account payment for Group 3. Figure 5.14, corresponding to Figure 5.9, depicts the new government expenditures under different policy characterizations. The patterns of Figure 5.14 and Figure 5.9 are similar, although net expenditures under the new assumption are higher on average. It is, once again, because residents in Group 3 contribute more in period 2 and the increase in government revenue is smaller then the increase in government expenditure.

Figure 5.14: Net Government Expenditures under Different Policy Characterizations If Utility in Period 3 Depends on Life Expectancy

I also present the effects of policy parameters on net government expenditure in Figure 5.15, based on which I obtain the same conclusions as Figure 5.10. Net government expenditure is the most elastic to T and the most inelastic to M. The signs of effects also remain unchanged.

Then I calculate the new unit net expenditures (i.e., unp) under different policy characterizations, and report their values in Figure 5.16. Similar to Figure 5.13, the new unit net expenditure reaches the minimum when $k = 55$, $M = 1,500$, $T = 179$, and $r^{one\ year} = 1.5\%$. My conclusions on policy effectiveness and government efficiency are still valid.

Figure 5.15: Net Government Expenditures When One Parameter Changes If Utility in Period 3 Depends on Life Expectancy

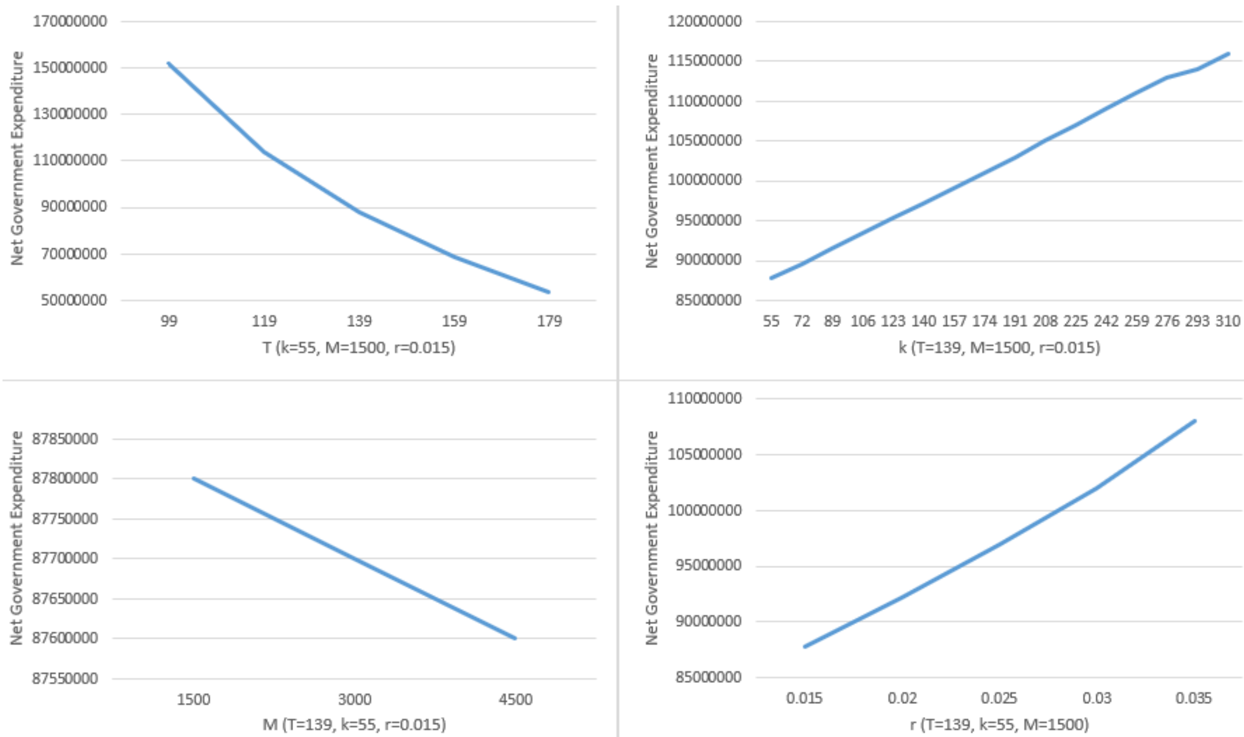


Table 5.33: Number of Group 3 Residents Contributing below and above the Maximum Contribution Level in Period 2 under Different Policy Parameter Characterizations If Utility in Period 3 Depends on Life Expectancy

Policy	Below	Above & $b < (1+r_1)(1+r_2)$	Above & $b > (1+r_1)(1+r_2)$
$k = 55, T = 99, r^{one\ year} = 1.5\%$	61	40	514
$k = 55, T = 99, r^{one\ year} = 3.5\%$	37	175	364
$k = 310, T = 99, r^{one\ year} = 1.5\%$	142	32	441
$k = 310, T = 99, r^{one\ year} = 3.5\%$	95	141	340
$k = 55, T = 179, r^{one\ year} = 1.5\%$	36	115	290
$k = 55, T = 179, r^{one\ year} = 3.5\%$	20	318	18
$k = 310, T = 179, r^{one\ year} = 1.5\%$	126	79	236
$k = 310, T = 179, r^{one\ year} = 3.5\%$	72	268	16

Finally we examine the impact of introducing the maximum contribution level under the new assumption. Following the same logic as Section 5.3.7, I calculate the number of residents in Group 3 contributing below and above the maximum level in Table 5.33. The proportions of residents contributing below the maximum level becomes lower, but the differences are

Figure 5.16: Unit Net Expenditures under Different Policy Characterizations If Utility in Period 3 Depends on Life Expectancy

not large. The main findings regarding the maximum contribution are identical.

To conclude, assuming that the utility in period 3 depends on life expectancy does not change the main simulation results that we are interested in. All the participation decisions and comparative statics are not affected. Although the magnitudes of optimal values and net expenditures may change, they still lead to the same qualitative conclusions. It indicates that this simulation analysis is independent of how I specify the utility in period 3, and we can trust the simulation results without the new assumption in place.

Chapter 6

Conclusions

In order to provide comprehensive support for the rapidly growing population of rural seniors, the Chinese government implemented NRSPI in 2009. Being the largest pension program in rural China (or even in the world), NRSPI has achieved national coverage and significantly reduced poverty since 2011 (Huang and Zhang, 2021). Given NRSPI's importance to old-age security in rural China, it is important to understand participation incentives, individual behaviors, and impacts of policy parameters for this program.

A large literature has empirically studied the determinants of NRSPI participation as well as the effects of NRSPI on individual behaviors, but the findings are, in many cases, contradictory. The ambiguity and inconclusiveness of these studies may stem in part from the lack of a solid conceptual foundation to underpin specification of empirical models. To address this problem, I have developed a three-period conceptual model that incorporates not only various individual parameters, but also key policy parameters related to NRSPI. The model first describes how life expectancy, as well as policy parameters, lead to heterogeneous individual participation decisions. I derived closed-form solutions for an individual's private savings, consumption, NRSPI participation decisions and, conditional on participating, their NRSPI contribution levels. I also provided a graphical analysis that offers clear intuitions about the trade-offs that individuals face in making these decisions. Comparative static analysis showed how individual demographic characteristics, such as life expectancy, and NRSPI policy parameters affect these decisions, as summarized in Tables 4.3, 4.4, and 4.5. Most comparative static results are still valid when life expectancy is incorporated into the utility function. My findings can help empirical studies decide the inclusion and exclusion of key regression variables, and provide testable hypotheses for them.

While I can conceptually derive the signs of NRSPI effects and comparative statics based on the conceptual model results, I am most interested in the magnitude of the effects of key individual and policy parameters. Knowing the magnitude of effects, I can evaluate the degree to which changing key NRSPI policy parameters will allow the government to achieve specific objectives, such as poverty reduction or reduction of regional inequality. With this motivation, I conducted a simulation analysis by randomly drawing 1,000 representative rural residents with heterogeneous individual characteristics. To ensure the simulation was reflective of the true demographics in rural China, I carefully selected the distributions of individual characteristics with the help of data from multiple sources. I also discussed the choices of policy parameters according to the current NRSPI policy. Based on simulation results, a number of key findings emerge which lead to specific policy implications and recommendations.

First, NRSPI as designed is already an attractive program for most rural residents in China, who expect to live past age 60. Simulation results indicate that over 90% of them can benefit from participating in NRSPI. The fact that actual participation rates are lower than what are suggested by the simulation implies the need for the program to be better promoted and to emphasize that it is beneficial for most individuals.

Second, different policy parameters have heterogeneous effects on the participation rate, as well as the proportion of residents contributing beyond the minimum. While the monthly basic pension payment and minimum contribution mainly affect the former, the policy-specified life span and annual normalized savings rate (driven by NRSPI interest rate) predominantly influence the latter. The government should carefully consider the impact of the key policy parameters in order to achieve their desired objectives.

Third, NRSPI participation is quite inelastic to policy parameters. The main reason is that the predicted participation rate is already very high given the baseline parameters. Consequently, making NRSPI more attractive does little to improve participation. High predicted participation is mainly due to the low level of minimum contribution compared to retirement benefits. As the minimum contribution is increased, the participation rate becomes lower and more elastic to the changes of parameters.

Fourth, optimal savings and NRSPI contribution also change with policy parameters. Participants with different contribution decisions react heterogeneously to the changes of parameters. Compared with the hypothetical case where there is no NRSPI, NRSPI participants save less before and during the contribution period, and the reduction in savings is even greater than the contribution. The crowding out effect is larger for those who contribute beyond the minimum when the monthly basic pension payment is high. In other words, the crowding out effect of NRSPI contribution is positively correlated with contribution and future benefits. It directly follows that consumption for participants increases throughout the life cycle, indicating that they have more to spend even if they need to pay for NRSPI contribution. NRSPI, as a secure source of income in the future, alleviates poverty for its participants in the current period. The results suggest that NRSPI can work together with rural Dibao, which is an unconditional transfer granted to poor rural Chinese residents. The social pension attribute of NRSPI, in the form of basic pension, is highlighted.

Fifth, net government expenditure on NRSPI is the most elastic to the policy-specified life span, followed by the size of the monthly basic pension payment and the annual normalized interest rate on private savings. With the exception of the interest rate on savings, the effects of other policy parameters on net government expenditure have the same sign as those on the participation rate. Therefore, it becomes very costly for the government to pursue a very high participation rate. The most efficient choice of policy parameters should improve the participation rate while maintaining relatively low net government expenditure. Based on this rule, the government should choose a high policy-specified life span, while making the other parameters as low as possible.

Sixth, regional heterogeneity of NRSPI participation rates is considerably large, given the fact that average life expectancy and basic pension benefits vary across provinces. Poorer provinces have lower average life expectancy, and in most cases set lower levels of basic pension benefits. As a result, participation rates in these provinces are low. Local governments fail to make NRSPI more attractive since they cannot meet the additional financial responsibility of enhancing basic pension benefits. Such a "vicious cycle" increases regional heterogeneity and inequality. To solve this problem, the central government in China should consider financially supporting poorer provinces to relieve the financial pressure of paying NRSPI benefits on local governments. With such support, local governments in poorer provinces will be able to attract more participants.

Seventh, a matching subsidy that is proportional to the NRSPI contribution effectively enhances the average contribution level of participants, but has almost no effect on the participation rate. Increasing the size of the basic pension payment and raising the matching subsidy rate yield heterogeneous results, for which reason they should not be considered as policy substitutes.

Eighth, given the fact that a portion of residents in Group 3 (those who contribute more than the minimum) will contribute in period 1 once I introduce the maximum contribution, the government may consider enhancing the maximum level. This portion of residents would be better off saving money in period 1 and then contributing more in period 2 if they could.

The simulation analysis is independent of how I specify the utility in period 3. We can trust the conclusions described above even if life expectancy does affect the marginal utility of consumption.

NRSPI was a significant policy innovation by the Chinese government to reduce rural poverty and income insecurity for rural seniors. NRSPI has become a success as measured by rising participation rates. However, more seniors still can benefit from joining NRSPI, and the government needs to do a better job of informing rural residents about the program and its benefits. To make NRSPI attractive and at the same time financially sustainable, the government should seek policy adjustments. This dissertation provides valuable guidelines for improving the program by demonstrating the impacts of individual and program parameters on the overall participation rate and on participation beyond the minimum contribution.

I conclude the dissertation by suggesting two future research directions. The first is to account explicitly for life expectancy in the utility function, which was discussed in the dissertation, but can be more comprehensive in the future. Deciding how life expectancy enters the utility function will be crucial to correctly evaluate the effects of life expectancy on individual behaviors. The second is to introduce uncertainty about life expectancy into the simulation model. In order to achieve this generalization, I would need to obtain data indicating how people view subjectively the range of their life expectancy.

References

Ahmed, W., A. Haider, and J. Iqbal. 2012. "Estimation of Discount Factor (Beta) and Coefficient of Relative Risk Aversion (Gamma) in Selected Countries." MPRA Paper No. 39736, University Library of Munich, Germany.

Andersen, S., G.W. Harrison, M.I. Lau, and E.E. Rutström. 2014. "Discounting Behavior: A Reconsideration." *European Economic Review* 71:15–33.

—. 2008. "Eliciting Risk and Time Preferences." *Econometrica* 76(3):583–618.

Andreoni, J., and C. Sprenger. 2012. "Estimating Time Preferences from Convex Budgets." *American Economic Review* 102(7):3333–3356.

Ang, J. 2009. "Household Saving Behaviour in an Extended Life Cycle Model: A Comparative Study of China and India." *Journal of Development Studies* 45(8):1344–1359.

Antolin, P., S. Payet, and J. Yermo. 2012. "Coverage of Private Pension Systems: Evidence and Policy Options." OECD Working Papers on Finance, Insurance and Private Pensions No. 20, OECD Publishing.

Ardington, C., A. Case, and V. Hosegood. 2009. "Labor Supply Responses to Large Social Transfers: Longitudinal Evidence from South Africa." *American Economic Journal: Applied Economics* 1(1):22–48.

Attanasio, O.P., and S. Rohwedder. 2003. "Pension Wealth and Household Saving: Evidence from Pension Reforms in the United Kingdom." *American Economic Review* 93(5):1499–1521.

Ayuso, M., J.M. Bravo, and R. Holzmann. 2017. "Addressing Longevity Heterogeneity in Pension Scheme Design and Reform." *Journal of Finance and Economics* 6(1):1–21.

Babat, S., D. Gultekin-Karakas, and M. Hisarciklilar. 2021. "An Appraisal of Turkey's Voluntary Individual Pension System from a Perspective of Pension Equality." *Social Policy & Administration* 55(5):784–801.

Bai, C., W. Chi, T.X. Liu, C. Tang, and J. Xu. 2021. "Boosting Pension Enrollment and Household Consumption by Example: A Field Experiment on Information Provision." *Journal of Development Economics* 150:102622.

Bai, C., B. Wu, and Y. Jin. 2012. "Effect of the Old-Age Insurance Contribution on Consumption and Savings." *Social Sciences in China* 33(8):48–71.

Beetsma, R.M.W.J., W.E. Romp, and S.J. Vos. 2012. "Voluntary Participation and Intergenerational Risk Sharing in a Funded Pension System." *European Economic Review* 56(6):1310–1324.

Bian, F., L. Zhang, R. Luo, and Q. Zhao. 2018. "The New Rural Social Pension Program in Rural China: Participation and Its Determinants." *Research of Agricultural Modernization* 39(1):80–86.

Bodie, Z., A.J. Marcus, and R.C. Merton. 1988. "Defined Benefit versus Defined Contribution Pension Plans: What Are the Real Trade-Offs?" In *Pensions in the US Economy*. Chicago, IL: University of Chicago Press, pp. 139–162.

Bond, C.A., K.G. Cullen, and D.M. Larson. 2009. "Joint Estimation of Discount Rates and Willingness to Pay for Public Goods." *Ecological Economics* 68(11):2751–2759.

Botelho, A., G.W. Harrison, L.M.C. Pinto, E.E. Rutström, and P. Veiga. 2006. "Discounting in Developing Countries: Experimental Evidence from Timor-Leste." Faculty Working Paper No. 31, Economics Department, University of Central Florida, Orlando, FL.

Bravo, J.M., M. Ayuso, R. Holzmann, and E. Palmer. 2021. "Addressing the Life Expectancy Gap in Pension Policy." *Insurance: Mathematics and Economics* 99:200–221.

Brzeziński, M. 2013. “Parametric Modelling of Income Distribution in Central and Eastern Europe.” *Central European Journal of Economic Modelling and Econometrics* 5(3):207–230.

Cai, F., J. Giles, P. O’Keefe, and D. Wang. 2012. *The Elderly and Old Age Support in Rural China*. Washington, D.C.: World Bank Publications.

Cai, Y., and Y. Cheng. 2014. “Pension Reform in China: Challenges and Opportunities.” *Journal of Economic Surveys* 28(4):636–651.

Calvo, E., L. Fang, and J.B. Williamson. 2016. “Rural Pension Reform: The Case of China.” *SSRN*. Available at: https://ssrn.com/abstract=2882145.

Casey, B.H., and J.M. Dostal. 2013. “Voluntary Pension Saving for Old Age: Are the Objectives of Self-Responsibility and Security Compatible?” *Social Policy & Administration* 47(3):287–309.

Castel, P. 2008. “Voluntary Defined Benefit Pension System Willingness to Participate the Case of Vietnam.” *SSRN*. Available at: https://ssrn.com/abstract=1379607.

Castro-González, S., L. Rey-Ares, S. Fernández-López, and D. Daoudi. 2020. “The Effect of Self-Control upon Participation in Voluntary Pension Schemes.” *Economics and Sociology* 13(1):11–23.

Catalan, M., and N.E. Magud. 2012. *A Tradeoff between the Output and Current Account Effects of Pension Reform*. Washington, D.C.: International Monetary Fund.

Chang, F., C. Yang, A. Wang, H. Wang, R. Luo, and Y. Shi. 2014. “Implementation of the New Rural Social Pension Program and the Factors Affecting Participation Behaviors: An Analysis Based on the Survey Data in 101 Villages in 5 Provinces (in Chinese).” *Management World* 30(3):92–101.

Chen, A., and N. Groenewold. 2017. "An Increase in the Retirement Age in China: The Regional Economic Effects." *Applied Economics* 49(7):702–721.

Chen, G., Q. Lv, and X. Chen. 2013. "Analysis on Disabled People's Situation and Well-Off in China in 2013 (in Chinese)." *Disability Research* 4(2):86–94.

Chen, T., and J.A. Turner. 2015. "Fragmentation in Social Security Old-Age Benefit Provision in China." *Journal of Aging & Social Policy* 27(2):107–122.

Chen, X. 2017. "Old Age Pension and Intergenerational Living Arrangements: A Regression Discontinuity Design." *Review of Economics of the Household* 15(2):455–476.

Chen, Y., L. Zhao, Y. Fan, and B. Xie. 2021. "Does the New Rural Pension Scheme Improve Residents' Livelihoods? Empirical Evidence from Northwestern China." *PLoS ONE* 16(4):e0250130.

Chen, Z., T. Bengtsson, and J. Helgertz. 2015. "Labor Supply Responses to New Rural Social Pension Insurance in China: A Regression Discontinuity Approach." IZA Discussion Paper No. 9360. https://ssrn.com/abstract=2672146.

Cheng, L., H. Liu, Y. Zhang, and Z. Zhao. 2018. "The Health Implications of Social Pensions: Evidence from China's New Rural Pension Scheme." *Journal of Comparative Economics* 46(1):53–77.

Chetty, R. 2006. "A General Formula for the Optimal Level of Social Insurance." *Journal of Public Economics* 90(10-11):1879–1901.

Chetty, R., J.N. Friedman, S. Leth-Petersen, T.H. Nielsen, and T. Olsen. 2014. "Active vs. Passive Decisions and Crowd-Out in Retirement Savings Accounts: Evidence from Denmark." *The Quarterly Journal of Economics* 129(3):1141–1219.

Chi, Z. 2022. "Effects of the New Rural Pension Scheme on the Income Distribution in Rural China." *Forest Chemicals Review* 24(2):1977–1989.

Choi, E.K. 2018. "Delegation and Then Intervention: The 2009 Decision to Create the New Rural Pension." *The China Quarterly* 233:64–84.

De Nardi, M., E. French, and J.B. Jones. 2009. "Life Expectancy and Old Age Savings." *American Economic Review* 99(2):110–115.

Ding, C., Y. Wu, S. Qin, and Z. Liang. 2019. "Social Trust and the Efficiency in the Implementation of Public Policies: Evidence from China's New Rural Pension Scheme." *Chinese Rural Economy* 35(5):109–123.

Ding, Y. 2017. "Personal Life Satisfaction of China's Rural Elderly: Effect of the New Rural Pension Programme." *Journal of International Development* 29(1):52–66.

Duflo, E. 2003. "Grandmothers and Granddaughters: Old-Age Pensions and Intrahousehold Allocation in South Africa." *The World Bank Economic Review* 17(1):1–25.

Ebenstein, A., and S. Leung. 2010. "Son Preference and Access to Social Insurance: Evidence from China's Rural Pension Program." *Population and Development Review* 36(1):47–70.

Frederick, S., G. Loewenstein, and T. O'donoghue. 2002. "Time Discounting and Time Preference: A Critical Review." *Journal of Economic Literature* 40(2):351–401.

Gao, Q., S. Yang, and F. Zhai. 2019. "Social Policy and Income Inequality during the Hu–Wen Era: A Progressive Legacy?" *The China Quarterly* 237:82–107.

Gao, W. 2012. "Factors Affecting the Participation in the New Rural Social Pension Insurance: Evidence from the Survey in Chengdu (in Chinese)." *Journal of Huazhong Normal University (Humanities and Social Sciences)* 51(4):55–61.

Guariglia, A., and S. Markose. 2000. "Voluntary Contributions to Personal Pension Plans: Evidence from the British Household Panel Survey." *Fiscal Studies* 21(4):469–488.

Guo, C. 2016. "New Rural Insurance Policy Changes the Rural Pension System: Yes or No? Empirical Study Based on CHALRS 2013 Data (in Chinese)." *Journal of Development-Oriented Finance Research* 2(6):63–75.

Gustman, A.L., and T.L. Steinmeier. 2015. "Effects of Social Security Policies on Benefit Claiming, Retirement and Saving." *Journal of Public Economics* 129:51–62.

Han, W., P. Wang, and H. Dong. 2020. "Influence of Egoistic and Altruistic Bequest Motives on the Willingness to Participate in Reverse Mortgages in China." *Asian Economic Journal* 34(4):430–463.

Hao, C., X. Zhao, and H. Zhang. 2021. "Can Social Pooling Elderly Care Crowd Out Family Intergenerational Elderly Care and Individual Self-Care: A Revalidation of the Effect of the New Rural Social Pension Insurance (in Chinese)." *Nankai Economics Studies* 37(6):144–161.

Hao, J., and J. Jia. 2011. "An Analysis on the Farmers' Will of Participation in the New Rural Social Old-Age Insurance in the Western Region (in Chinese)." *Northwest Population* 32(2):107–110.

Harrison, G.W., M.I. Lau, and M.B. Williams. 2002. "Estimating Individual Discount Rates in Denmark: A Field Experiment." *American Economic Review* 92(5):1606–1617.

He, H., and X. Li. 2020. "Evaluation of the Impact of the New Rural Social Pension Insurance Policy on Rural Residents' Consumption." *Journal of Jiangxi University of Finance and Economics* 22(3):61–72.

He, L., and Z. Jiang. 2015. "The Effect on Consumption Enhancement of the New Rural Social Pension Insurance: Evidence from CHARLS (in Chinese)." *Population & Economics* 36(1):116–125.

Heenkenda, S. 2016. "Determinants of Dropouts from Voluntary Pension Scheme: Evidence from Sri Lanka." *International Journal of Business and Management Society* 1(1):10–22.

Hlasny, V. 2021. "Parametric Representation of the Top of Income Distributions: Options, Historical Evidence, and Model Selection." *Journal of Economic Surveys* 35(4):1217–1256.

Holzmann, R., and R. Hinz. 2005. *Old-Age Income Support in the 21st Century: An International Perspective on Pension Systems and Reform*. Washington, D.C.: World Bank Publications.

Hsu, Y., H. Yoshida, and F. Chen. 2022. "The Impacts of Population Aging on China's Economy." *Global Journal of Emerging Market Economies* 14(1):105–130.

Hu, H., J. Xu, and X. Zhang. 2020. "The Role of Housing Wealth, Financial Wealth, and Social Welfare in Elderly Households' Consumption Behaviors in China." *Cities* 96:102437.

Hua, Y., H. Zhang, and H. Liu. 2022. "Does Pension Affect Labour Supply? New Evidence from Large-Scale Rural Pension Policy Reform in China." *Applied Economics* 54(11):1212–1228.

Huang, H., and H. Hu. 2018. "The Impact of New Rural Society Endowment Insurance on the Survival Consumption of Rural Households: Evidence from CHARLS Data (in Chinese)." *Issues in Agricultural Economy* 39(5):18–26.

Huang, W., and C. Zhang. 2021. "The Power of Social Pensions: Evidence from China's New Rural Pension Scheme." *American Economic Journal: Applied Economics* 13(2):179–205.

Issler, J.V., and N.S. Piqueira. 2000. "Estimating Relative Risk Aversion, the Discount Rate, and the Intertemporal Elasticity of Substitution in Consumption for Brazil Using Three Types of Utility Function." *Brazilian Review of Econometrics* 20(2):201–239.

Jäntti, M., E.M. Sierminska, and P. Van Kerm. 2015. "Modeling the Joint Distribution of Income and Wealth." In *Measurement of Poverty, Deprivation, and Economic Mobility*.

Bingley, West Yorkshire, England: Emerald Group Publishing Limited, vol. 23, pp. 301–327.

Jensen, R.T., and K. Richter. 2004. "The Health Implications of Social Security Failure: Evidence from the Russian Pension Crisis." *Journal of Public Economics* 88(1-2):209–236.

Jiang, P. 2020. "The Lump-Sum and Structural Effects of the New Rural Social Pension Insurance on the Consumption of Rural Households (in Chinese)." *Shanxi Agricultural Economy* 38(19):1–9.

Jiao, K., and Y. Jing. 2014. "The Analysis of the Saving Crowding-out Effect of New Rural Social Endowment Insurance and Its Influencing Factors: Based on the Extension of the Intergenerational Model for Two periods (in Chinese)." *Northwest Population* 35(2):110–114.

Jin, G., and Q. Liu. 2013. "Research on the Incentive Effect of the Financial Subsidy of the Individual Account of the New Rural Pension System (in Chinese)." *Population & Economics* 34(1):92–100.

Jin, W., P. Wang, and L. He. 2018. "A Research on the Security Role of New Rural Pension Scheme: Theoretical Mechanisms and Empirical Evidence." *Journal of Finance and Economics* 44(11):125–138.

Juarez, L. 2009. "Crowding Out of Private Support to the Elderly: Evidence from a Demogrant in Mexico." *Journal of Public Economics* 93(3-4):454–463.

Kmietowicz, Z.W., and H. Ding. 1993. "Statistical Analysis of Income Distribution in the Jiangsu Province of China." *Journal of the Royal Statistical Society: Series D (The Statistician)* 42(2):107–121.

Kovacs, K.F., and D.M. Larson. 2008. "Identifying Individual Discount Rates and Valuing Public Open Space with Stated-Preference Models." *Land Economics* 84(2):209–224.

Landerretche, O.M., and C. Martínez. 2013. “Voluntary Savings, Financial Behavior, and Pension Finance Literacy: Evidence from Chile.” *Journal of Pension Economics & Finance* 12(3):251–297.

Lei, X., C. Zhang, and Y. Zhao. 2013. “Incentive Problems in China’s New Rural Pension Program.” In *Labor Market Issues in China*. Bingley, West Yorkshire, England: Emerald Group Publishing Limited, pp. 181–201.

Li, J., X. Wang, J. Xu, and C. Yuan. 2020. “The Role of Public Pensions in Income Inequality among Elderly Households in China 1988-2013.” *China Economic Review* 61:101422.

Li, Q., Y. Wang, and Y. Zhao. 2018. “The Impact of China’s New Rural Pension Program on Elderly Labor, Grandchild Care, and Old-Age Support.” *Feminist Economics* 24(2):265–287.

Li, Y., and H. Cui. 2014. “Factors Affecting Promoting New Rural Social Endowment Insurance from the Perspective of Consumer Behavior (in Chinese).” *Journal of Agro-Forestry Economics and Management* 13(1):24–31.

Lin, B., Z. Lin, Y.Y. Zhang, and W. Liu. 2018. “The Impact of the New Rural Pension Scheme on Retirement Sustainability in China: Evidence of Regional Differences in Formal and Informal Labor Supply.” *Sustainability* 10(12):4366.

Lin, B., and Y. Wang. 2012. “An Empirical Analysis of Differences between the Will and Behaviors of Farmers’ Participation in the New Rural Social Pension Program: A Case Study of Fujian (in Chinese).” *Finance & Trade Economics* 37(7):29–38.

Lin, B., and Y.Y. Zhang. 2019. “The Impact of Fiscal Subsidies on the Sustainability of China’s Rural Pension Program.” *Sustainability* 12(1):186.

Liu, A. 2019. “The Effects of the New Rural Pension Insurance on Household Asset Allocation.” *Journal of Finance and Economics* 40(6):76–81.

Liu, E.M. 2013. "Time to Change What to Sow: Risk Preferences and Technology Adoption Decisions of Cotton Farmers in China." *Review of Economics and Statistics* 95(4):1386–1403.

Liu, H. 2020. "New Plan and Traditional Practices: New Rural Pension Scheme and Elderly's Reliance on Their Adult Children." *International Journal of Social Science and Education Research* 3(4):93–106.

Liu, H., X. Han, Q. Xiao, S. Li, and M.W. Feldman. 2015. "Family Structure and Quality of Life of Elders in Rural China: The Role of the New Rural Social Pension." *Journal of Aging & Social Policy* 27(2):123–138.

Liu, H., and L. Xu. 2014. "The Empirical Analysis of Factors Affecting Farmers' Will to Participate in the New Rural Social Pension Insurance: Evidence from the Survey on 428 Farmers in Hunan Province (in Chinese)." *Rural Economy* 32(2):55–60.

Liu, T., and L. Sun. 2016. "Pension Reform in China." *Journal of Aging & Social Policy* 28(1):15–28.

Loyalka, P., L. Liu, G. Chen, and X. Zheng. 2014. "The Cost of Disability in China." *Demography* 51(1):97–118.

Lu, H. 2012. "The Reasons for the Popularity of the Lowest Range of the New Rural Endowment Insurance and Countermeasure Analysis (in Chinese)." *Social Security Studies* 5(2):20–28.

Ma, G., and G. Zhou. 2014. "The Impacts of New Rural Pension Program on Household Saving: Evidence from CFPS (in Chinese)." *Economic Research Journal* 49(11):116–129.

Ma, H. 2016. "Study on the Influence of Individual Capability and Social Trust on the Participation of New Rural Endowment Insurance: Based on the Selection of Decision Process View (in Chinese)." *Statistics & Information Forum* 31(3):44–51.

Ma, X. 2020. "The Impact of the New Rural Pension Scheme on Labor Supply of Intra-Household Prime-Age Adults in Rural China." *Journal of Chinese Economic and Business Studies* 18(1):51–72.

Madrian, B.C., and D.F. Shea. 2001. "The Power of Suggestion: Inertia in 401 (k) Participation and Savings Behavior." *The Quarterly Journal of Economics* 116(4):1149–1187.

Malley, J., R. Hancock, M. Murphy, J. Adams, R. Wittenberg, A. Comas-Herrera, C. Curry, D. King, S. James, and M. Morciano. 2011. "The Effect of Lengthening Life Expectancy on Future Pension and Long-Term Care Expenditure in England, 2007 to 2032." *Health Statistics Quarterly* 52(1):33–61.

Marcinkiewicz, E. 2016. "Do We Need Voluntary Pension Schemes? The Role of Voluntariness in a Pension System." *Problemy Polityki Społecznej. Studia i Dyskusje* 33(2):71–85.

—. 2017. "Factors Affecting the Development of Voluntary Pension Schemes in CEE Countries: A Panel Data Analysis." *Central European Economic Journal* 3(50):26–40.

Mastrobuoni, G. 2009. "Labor Supply Effects of the Recent Social Security Benefit Cuts: Empirical Estimates Using Cohort Discontinuities." *Journal of Public Economics* 93(11-12):1224–1233.

McDonald, J.B., and D.O. Richards. 1987. "Hazard Rates and Generalized Beta Distributions." *IEEE Transactions on Reliability* 36(4):463–466.

Mi, H., N. Jia, and W. Zhou. 2016. "Forecast of Income and Expenses of New Style Rural Old-Age Insurance in Future 70 Years and Its Institutional Improvement (in Chinese)." *Journal of Northwest A&F University (Social Science Edition)* 16(4):1–10.

Mu, H., and L. Yan. 2012. "Factors Affecting Farmers' Participation in the New Rural Pension Insurance (in Chinese)." *Population Research* 36(1):73–82.

National Bureau of Statistics of China. 2021a. *China Statistical Yearbook 2021*. Beijing, China: China Statistics Press.

—. 2021b. *Communiqué of the Seventh National Population Census*. Beijing, China, May.

Nie, J., and Z. Zhong. 2014. "A Study on the Sustainability of Securing Ability of the New Rural Social Pension Insurance: Based on the Perspective of Contribution Level Choices of Rural Residents (in Chinese)." *Journal of Public Management* 11(3):70–79.

Ning, M., W. Liu, J. Gong, and X. Liu. 2019. "Does the New Rural Pension Scheme Crowd out Private Transfers from Children to Parents? Empirical Evidence from China." *China Agricultural Economic Review* 11(2):411–430.

Niu, G., Y. Zhou, and H. Gan. 2020. "Financial Literacy and Retirement Preparation in China." *Pacific-Basin Finance Journal* 59:101262.

Pan, G., S. Li, Z. Geng, and K. Zhan. 2021. "Do Social Pension Schemes Promote the Mental Health of Rural Middle-Aged and Old Residents? Evidence from China." *Frontiers in Public Health* 9:710128.

Pender, J.L. 1996. "Discount Rates and Credit Markets: Theory and Evidence from Rural India." *Journal of Development Economics* 50(2):257–296.

Peng, X. 2021. "Coping with Population Ageing in Mainland China." *Asian Population Studies* 17(1):1–6.

Ridho, S.L.Z., H.B.H.M. Sabli, and H. Setiawan. 2021. "The Cross-Provincial Data of Life Expectancy Effect on Pension Fund in Indonesia." *International Journal of Social Science and Business* 5(2):193–199.

Romp, W.E., and R.M.W.J. Beetsma. 2020. "Sustainability of Pension Systems with Voluntary Participation." *Insurance: Mathematics and Economics* 93:125–140.

Rudolph, H.P. 2016. "Building Voluntary Pension Schemes in Emerging Economies." World Bank Policy Research Working Paper No. 7779, World Bank.

Saitone, T.L., R.J. Sexton, and B. Malan. 2018. "Price Premiums, Payment Delays, and Default Risk: Understanding Developing Country Farmers' Decisions to Market Through a Cooperative or a Private Trader." *Agricultural Economics* 49(3):363–380.

Sánchez-Romero, M., and A. Prskawetz. 2017. "Redistributive Effects of the US Pension System among Individuals with Different Life Expectancy." *The Journal of the Economics of Ageing* 10:51–74.

Sane, R., and S. Thomas. 2015. "In Search of Inclusion: Informal Sector Participation in a Voluntary, Defined Contribution Pension System." *The Journal of Development Studies* 51(10):1409–1424.

Shen, C., J. Johnson, Z. Chi, and J.B. Williamson. 2020. "Does a Universal Non-Contributory Social Pension Make Sense for Rural China?" *International Social Security Review* 73(2):3–26.

Shen, Z., X. Zheng, and H. Yang. 2020. "The Fertility Effects of Public Pension: Evidence from the New Rural Pension Scheme in China." *PLoS ONE* 15(6):e0234657.

Shi, X. 2022. "Land Reallocation Responses to China's New Rural Pension Scheme: Evidence from a Regression Discontinuity Design." *Journal of Rural Studies* 92:35–49.

Shu, L. 2015. "A Small Amount Can Make a Big Difference: The Effect of the New Rural Social Pension Insurance Program on the Retirement Decision in China." Netspar Discussion Paper No. 12/2015-056. Available at: https://ssrn.com/abstract=2726663.

Stepan, M., and Q. Lu. 2016. "The Establishment of China's New Type Rural Social Insurance Pension: A Process Perspective." *Journal of Current Chinese Affairs* 45(2):113–147.

Stevens, T.H., N.E. DeCoteau, and C.E. Willis. 1997. "Sensitivity of Contingent Valuation to Alternative Payment Schedules." *Land Economics* 73(1):140–148.

Su, B. 2017. "Pensions and Household Consumption in Rural China." *China Agricultural Economic Review* 9(4):522–534.

Tanaka, T., C.F. Camerer, and Q. Nguyen. 2010. "Risk and Time Preferences: Linking Experimental and Household Survey Data from Vietnam." *American Economic Review* 100(1):557–71.

Tang, L., S. Sun, and W. Yang. 2021. "Investments in Human Capital: The Evidence from China's New Rural Pension Scheme." *Research in International Business and Finance* 55:101345.

Tao, D., J. Wang, H. Cai, and K. Zhao. 2021. "Do Kinship Networks Crowd Out the New Rural Pension Plan in China? Policy Implications for an Aging China." *The Singapore Economic Review* 66(6):1647–1663.

Tao, J. 2017. "Can China's New Rural Social pension Insurance Adequately Protect the Elderly in Times of Population Ageing?" *Journal of Asian Public Policy* 10(2):158–166.

Van Dalen, H.P., and K. Henkens. 2018. "Do People Really Want Freedom of Choice? Assessing Preferences of Pension Holders." *Social Policy & Administration* 52(7):1379–1395.

Walczak, D., J. Wantoch-Rekowski, and R. Marczak. 2021. "Impact of Income on Life Expectancy: A Challenge for the Pension Policy." *Risks* 9(4):65.

Wang, D. 2006. "China's Urban and Rural Old Age Security System: Challenges and Options." *China & World Economy* 14(1):102–116.

Wang, F., and D. Deborah. 2009. "Poverty and Wealth in Post-Socialist China: An Overview." In D. Davis and W. Feng, eds. *Creating Wealth and Poverty in Post-Socialist China*. Stanford, CA: Stanford University Press, pp. 3–17.

Wang, F., and H. Zheng. 2021. "Do Public Pensions Improve Mental Wellbeing? Evidence from the New Rural Society Pension Insurance Program." *International Journal of Environmental Research and Public Health* 18(5):2391.

Wang, H., and J. He. 2018. "Implicit Individual Discount Rate in China: A Contingent Valuation Study." *Journal of Environmental Management* 210:51–70.

Wang, H., and J. Huang. 2021. "How Can China's Recent Pension Reform Reduce Pension Inequality?" *Journal of Aging & Social Policy*. Available at: https://doi.org/10.1080/08959420.2021.1926865.

Wang, H., J. Huang, and S. Sun. 2019. "Assessment of the Financial Sustainability of China's New Rural Pension Plan: Does the Demographic Policy Reform Matter?" *Sustainability* 11(18):5110.

Wang, J., B. He, and J. Bi. 2022. "New Rural Pension Program and Poverty Vulnerability of Rural Low Income Households: A Study Based on Precision Poverty Alleviation Policy and Different Poverty Standards." *Economic Theory and Business Management* 42(3):85–99.

Wang, L., and D. Béland. 2014. "Assessing the Financial Sustainability of China's Rural Pension System." *Sustainability* 6(6):3271–3290.

Wang, X. 2017. "Does the New Rural Pension Program Improve the Residents' Consumption Levels: A Study Based on CFPS Database (in Chinese)." *South China Journal of Economics* 36(1):1–12.

Wang, Y. 2011. "Factors Influencing Participation of the New Rural Social Pension Insurance: A Logit Regression Model Based on the Survey of Rural Households (in Chinese)." *Rural Economy* 29(7):92–101.

Wang, Z., Y. Zhou, and Y. Zhu. 2013. "Is the Relationship between Raising Children to Provide against Old Age and the New Agricultural Insurance Alternative or Complementary?

Take the Cities of Xiamen, Zhangzhou and Longyan as Example (in Chinese)." *Economic Issues in China* 55(6):20–27.

Warner, J.T., and S. Pleeter. 2001. "The Personal Discount Rate: Evidence from Military Downsizing Programs." *American Economic Review* 91(1):33–53.

Wu, J., Y.Y. Zhang, and B. Lin. 2021. "The Impact of Trust in Government on Rural Residents' Participation in China's New Rural Pension Scheme." Paper presented at International Conference of Agricultural Economists, online, 17-31 August.

Wu, L. 2013. "Inequality of Pension Arrangements among Different Segments of the Labor Force in China." *Journal of Aging & Social Policy* 25(2):181–196.

Xia, L., and Q. Jin. 2021. "Study on the Impact of Endowment Insurance on Residents' Quality of Life: Analysis Based on CFPS (2018) Micro Data (in Chinese)." *Advances in Applied Mathematics* 10(10):3295–3307.

Xu, Q., W. Ma, F. Wang, Q. Yang, and J. Liu. 2022. "Social Pensions and Risky Financial Asset Holding in China." *Applied Economics* 54(29):3412–3425.

Xu, S., and J. Zhang. 2022. "Do Social Pensions Affect the Physical and Mental Health of Rural Children in China? An Intergenerational Care Perspective." *International Journal of Environmental Research and Public Health* 19(7):3949.

Xu, T. 2021. "Rural Pension System and Farmers' Participation in Residents' Social Insurance." MPRA Paper No. 112032, University Library of Munich, Germany.

Yang, X., and L. Gan. 2020. "Bequest Motive, Household Portfolio Choice, and Wealth Inequality in Urban China." *China Economic Review* 60:101399.

Yang, Y., and W. Zhou. 2017. "Regional Disparities in China's Basic Pension Insurance and Labor Migration." *The Chinese Economy* 50(5):323–338.

Yao, J. 2015. "Rational Choice, Extrinsic Motivation and Peasants' Continuous Participation in New-Type Rural Social Pension Insurance: Based on Four Provinces Survey Data (in Chinese)." *Chinese Journal of Population Science* 29(4):111–120.

You, J., and M. Niño-Zarazúa. 2019. "The Intergenerational Impact of China's New Rural Pension Scheme." *Population and Development Review* 45(51):47–95.

Zhang, C. 2010. "Farmers' Will to Participate in the New Rural Social Pension Insurance and Its Determinants: Evidence from the Survey in Doumen and Maonan Districts in Guangdong Province (in Chinese)." *Journal of Agrotechnical Economics* 29(6):4–10.

Zhang, C., J. Giles, and Y. Zhao. 2014. "Policy Evaluation of China's New Rural Pension Program: Income, Poverty, Expenditure, Subjective Wellbeing and Labor Supply (in Chinese)." *China Economic Quarterly* 14(1):203–230.

Zhang, C., Y. Li, and Z. Hu. 2017. "Social Pension, Old-Age Support and the Sex Ratio Bias (in Chinese)." *China Economic Quarterly* 18(2):749–770.

Zhang, H., M. Yang, and Q. Ma. 2009. "Factors Influencing the Development of Rural Pension System: An Empirical Analysis Based on Farmers' Participation Intention (in Chinese)." *Journal of South China Agricultural University (Social Science Edition)* 8(3):11–17.

Zhang, L., Z. Ding, and L. Qiu. 2019. "Old Age Care Preferences Among Chinese Middle-Aged Single-Child Parents and the Related Policy Implications." *Journal of Aging & Social Policy* 31(5):393–414.

Zhang, Y., and Y. Wang. 2019. "The Influence of the New Rural Social Pension Insurance on Poverty-Stricken Population: Based on an Analysis of CHARLS 2011-2015 Panel Data (in Chinese)." *Insurance Studies* 40(5):69–80.

Zhang, Z., Y. Luo, and D. Robinson. 2019. "Who Are the Beneficiaries of China's New Rural

Pension Scheme? Sons, Daughters, or Parents?" *International Journal of Environmental Research and Public Health* 16(17):3159.

Zhao, C., and X. Qu. 2021. "Peer Effects in Pension Decision-Making: Evidence from China's New Rural Pension Scheme." *Labour Economics* 69:101978.

Zhao, L. 2020. "The Effects of Regional Heterogeneity and Education on Farmers' Pension Participation Behaviors (in Chinese)." *Jiangsu Agriculture Science* 48(4):310–316.

Zhao, Q., S. Brosig, R. Luo, L. Zhang, A. Yue, and S. Rozelle. 2016. "The New Rural Social Pension Program in Rural China: Participation and Its Correlates." *China Agricultural Economic Review* 8(4):647–661.

Zhao, Q., Z. Li, and T. Chen. 2016. "The Impact of Public Pension on Household Consumption: Evidence from China's Survey Data." *Sustainability* 8(9):890.

Zheng, C., and X. Wang. 2020. "The Impact of China's New Rural Pension Scheme on the Rural Elderly's Poverty." *Journal of Finance and Economics* 46(3):124–138.

Zheng, H., and T. Zhong. 2016. "The Impacts of Social Pension on Rural Household Expenditure: Evidence from China." *Journal of Economic Policy Reform* 19(3):221–237.

Zheng, W., Z. Liu, and R. Jia. 2019. "How Private Sector Participation Improves Retirement Preparation: A Case from China." *The Geneva Papers on Risk and Insurance - Issues and Practice* 44(1):123–147.

Zheng, X., X. Fang, and D.S. Brown. 2020. "Social Pensions and Child Health in Rural China." *The Journal of Development Studies* 56(3):545–559.

Zheng, X., S. Shangguan, Z. Shen, and H. Yang. 2022. "Social Pensions and Children's Educational Outcomes: The Case of New Rural Pension Scheme in China." *Journal of Family and Economic Issues* 43(2):1–19.

Zhong, Z., and F. Li. 2012. "Mobilization Effect and Economic Rationality: The Behavior Logic of Peasant Households' Participation in New-Type Rural Social Pension Insurance: A Survey Based on Shuangliu Street, Xinzhou District in Wuhan (in Chinese)." *Sociological Studies* 27(3):139–156.