The Sustainability of Chinese Pay-As-You-Go Pension System in Urban Areas

Thesis submitted in accordance with the requirements of

the University of Liverpool for the degree of Doctor in Philosophy

by

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June 2017

Abstract

A pay-as-you-go (PAYG) pension system requires a balance between the benefits paid to pensioners and the contributions made by active workers. The decline in fertility rates and the increase in longevity in China will lead to a substantial increase in the old-age dependency ratio, raising serious concerns about the long-term sustainability of the Chinese pension system.

This thesis provides the first estimate of the sustainability of the Chinese PAYG pension system in urban areas and is based on two actuarial balance methodologies. The first is the Swedish solvency ratio, which is based on verifiable facts. The second is the United States' actuarial balance indicator, which takes into account projected demographic and economic structures. Both methodologies show that the Chinese pension system, in its current form, is unsustainable. Two factors, namely the one-child policy and the urbanization process, that affect the sustainability of the Chinese pension system are analysed. Population projections under different demographic structures are provided using the cohort component method, and an automatic balancing mechanism is designed in order to restore the sustainability of this pension system. The main finding is that the one-child policy is harmful to the system's sustainability. Furthermore, all scenarios studied show there is an urgent need to introduce mechanisms that will guarantee long-term sustainability of the system. The analysis of the urbanization process shows that demographic changes due to rural-urban migration will have an enormous impact on the Chinese PAYG pension system. Contrary to the current public hypothesis that a huge inflow of a working-age population will restore the demographic balance between contributors and pensioners, the rapid urbanization process will result in a higher old-age dependency ratio after 2050. Overall, urbanization worsens the long-term sustainability of the Chinese pension system.

Acknowledgement

I would like to thank my supervisor Dr. María del Carmen Boado-Penas for her tremendous support and encouragement throughout my PhD study. This thesis could not be completed without her original ideas. Thank you for training me to grow as a research scientist. Your advice on both research as well as on my career has been invaluable.

Many thanks to all the staffs and students in Institute for Financial and Actuarial Mathematics (IFAM), thank you for providing such a lovely environment for me to learn and grow. Special thanks to my two examiners: Prof. Peter Lawrence and Dr. Hirbod Assa, it is my great honour to have you as my examiners.

Finally but not the least, biggest thanks to my family, thanks for your support during my PhD study and in my life, love you all.

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Chapter 1

Introduction

The vast majority of countries around the world including China chose the pay-as-you-go (PAYG) systems at the establishment of their public pensions and keep this form till now (OECD, 2015). The PAYG pension system works in the way that current active workers pay the benefits for current retirees. It requires a balance between the expenditures paid on pensions and the income from contributions. The PAYG system is facing severe challenges in the context of global ageing, which is caused by the increasing longevity and decreasing fertilities. Longevity is, of course, a good thing as people are living longer now than ever before. However, the duration of the payment periods is longer in the respect of pensions, which will lead to the increase of the expenditures in the system. The life expectancy at birth[1] around the world is 46.81 years old in 1950,

[1]Life expectancy at birth is defined as the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life (United Nations, 2015).

and it is 70.47 now, which means people now are living more than 20 years longer than they were 60 years ago. Furthermore, United Nations (2015) projects the life expectancy will keep raising and reach 81.53 in 2080. On the other side, the world average fertility rate keeps decreasing from 4.96 (children per woman) in 1950 to current 2.51. United Nations (2015) also projects that the fertility rate will keep decreasing in the future to 2.05 in 2080. The decline of the fertilities will lead to the shrinking of the working-age population, and hence reduce the income from contributions in a PAYG pension system. A decline in the fertility together with an increase in the longevity will result in a substantial increase in the old-age dependency ratio[2], it thus leads to serious concerns about the sustainability of PAYG pension systems. The challenges faced by China is more severe, as the one-child policy which was conducted in the 1980s has led to the rapid decline in the fertility rates, and at the same time, the first cohort of baby boomers who were born in the 1950s are approaching retirement now. Thus, the analysis of the current PAYG pension system together with the presentation for corresponding pension reforms becomes not only necessary but also urgent in China. This thesis provides the first estimate of the long-term sustainability of Chinese PAYG pension system. While previous literature usually focuses on the short-term liquidity, i.e. each year's pension expenditures minus each year's income from contributions. This thesis also analyses how the current political and social events in China affect the long-term sustainability of its pension system. This is the first time that the impact of one-child policy has been analysed on the pension system, while the previous studies always focus on its impact on the economic growth and children's health. Based

[2]The old-age dependency ratio is defined as the number of elder people divided by the number of working-age population.

on the cohort component method, I analyse the impact of one-child policy by adjusting the total fertility rates in the population projections under different demographic scenarios. We also set up automatic balance mechanism (ABM) under the different demographic structures to restore the sustainability of the Chinese pension system. The ABM provides us with the optimal paths of the contribution rate, retirement age and the indexation of pensions, which give us a clear view of how the different fertility policies could affect the sustainability of the Chinese pension system. Along with the country's fast economic growth, the implications of the urbanization process has been widely discussed in the areas of environmental health and people's living standards. However, its impact on the pension system has never been investigated so far. Thus, I analyse the impact of the urbanization on the Chinese pension system in this thesis by introducing a rural to urban migration rates into the cohort component model. The comparison of the ABM between the migration scenario and the baseline scenario (without the rural to urban migration) shows the impact of the urbanization process on the long-term sustainability of the Chinese PAYG pension system. A brief description of each chapter in this thesis are described in the following, and the structure of the thesis is given at the end of this chapter.

A pension is an important part of a country's social security system. It helps to prevent poverty among elderly people and ensures decent living standards after their retirements. The sustainability of a pension system has drawn much attention around the world in the context of the recent trend of global ageing. A lot of countries has already conducted some pension reforms in order to obtain the adequacy and sustainability of

their pension systems. Chapter 2 introduces some basic concepts in the pension system and gives examples in a global context.

Chapter 3 focuses on the pension systems in China. It describes the whole evolution of the entire public pension system from its beginning to current status at first, and then focus on the PAYG pension system in our analysis. This chapter also assesses the current problems in the Chinese pension system and discusses the future directions of pension reforms in China. Pension reforms in China have drawn much attention around the world recently, after the country's rapid economic growth. The problems such as 'empty accounts' and severe ageing have led to serious concerns in the pension system. This chapter shows that the analysis of the pension system in China and the implementation of the pension reforms to restore the sustainability are demographically urgent, economically necessary and socially and politically essential.

With the objective of evaluating the current financial status of the Chinese pension system and providing the possible parametric reforms, I analyse the long-term sustainability of the system using two different actuarial methodologies in the fourth chapter. One is Swedish actuarial balance sheet model, which is based on verifiable facts. The Swedish model assumes a steady state, i.e. neither the demographic nor the economic structures of the pension system will change in the future. It analyses the long-term sustainability of the pension system in its current circumstances. The other is U.S. actuarial balance indicator model, which involves projections on future demographic and economic changes. The U.S. model calculates the difference between the incomes

and the expenditures of the pension system in the next 75 years. The evolution of the demographic and economic changes is taken into account during its calculation.

As mentioned before, the rapid decline in the fertility rates in China was mainly due to the one-child policy[3], which was introduced in 1979 by the Chinese government with the aim of controlling the country's rapid population growth. The consequences of the one-child policy on the Chinese future economic growth have been widely discussed during the last three decades after its implementation. The contributions of the one-child policy to the country's economic growth have been confirmed (McElroy and Yang, 2000; Li et al., 2005; Li and Zhang, 2007). However, some authors have raised concerns that the one-child policy would lead to the serious labour shortage which is not compatible with the country's objective of economic advancement (Bloom and Williamson, 1998; Howden and Zhou, 2014). In terms of the pension system, the demographic change caused by the one-child policy will also affect the sustainability of a PAYG pension system. The decrease in the number of contributors and the relative increase in the number of pensioners, i.e. an increase in the old-age dependency ratio would lead to deficits in the Chinese pension system. With this in mind, I analyse the impact of the one-child policy on the sustainability of the Chinese pension system in the fifth chapter.

The fast economic growth in China has led to the rapid urbanization, which has drawn a lot of attention in the world. The urbanization rate (defined as the number of popu-

[3]One-child policy is a compulsory policy that does not allow to have more than one child in any Chinese family. Refer to Banister (1987), Chen and Kols (1982) and Lin and Zhou (1984) for more detailed information on one-child policy.

lation living in the urban area divided by the total population in percentage) in China has expanded from 12% to 50% in 6 decades between 1950 and 2011, while the same transition took 150 years to occur in Europe and 210 years in Latin America and the Caribbean. The urbanization is linked with sustainable development. In the aspect of advantages, urbanization can facilitate economic and social development by concentrating the human resources in the urban area (Cohen, 2006; Grübler and Fisk, 2013). However, rapid and unplanned urban growth also leads to some disadvantages, such as environmental degradation and the inequalities between the urban poor and the urban rich citizens (Angel et al., 2011b; Balk et al., 2009; Fink et al., 2014). The key reason behind the fast urbanization in China is the change of demographic structures due to the rural to urban migration (Dyson, 2011), and the demographic change will have an enormous impact on the PAYG pension system. Thus, I analyse the impact of the urbanization process on the sustainability of the Chinese PAYG pension system in urban areas in the sixth chapter.

Following this introduction, Chapter 2 describes the pensions in a global context. This chapter explains some basic concepts in the pension system and overviews the pension systems and recent pension reforms around the world. After that, Chapter 3 focuses on the pension system in China. It describes the evolution of the entire Chinese pension system at first, and then reviews the current problems of the pension system and summarizes the future directions of the pension reforms in China. Chapter 4 uses two different actuarial methodologies to analyse the long-term sustainability of the current Chinese PAYG pension system. An actuarial balance sheet for China is compiled based

on Swedish method with a solvency ratio (SR) derived from the assets and the liabilities for China. Then an actuarial balance indicator (AB) for China based on the United States' method is provided, which analyses the sustainability of the Chinese pension system over the next 75 years. Following that in Chapter 5, we analyse the implications of the one-child policy on the sustainability of the pension system. Population projections under different demographic structures regarding the various fertility policies are provided in this chapter. We also set up an ABM for the Chinese PAYG pension system in order to restore the sustainability. The implications of the urbanization process on the sustainability of the Chinese pension system is analysed in Chapter 6 by adjusting the net migration rates for the impact of rural to urban migration. Finally, Chapter 7 concludes the thesis.

Chapter 2

Pensions in a Global Context

This chapter describes the pension system in a global context and discusses the pension reforms around the world. A Pension is the income people can receive after their retirement to replace the earnings from employment, and its design should following two principle objectives – pension adequacy and financial sustainability (Sullivan, 2004). The target of pension adequacy is to prevent elder people from poverty and secure a decent living standard after their retirement. At the same time, the paramount objective of a pension system is to obtain the financial sustainability in the long term, i.e. to achieve the financial balance between the income from contributions and the expenditures of pension payments. Financial sustainability is very important to a PAYG pension system in the current context of rapid ageing, since the increase of longevity and the decreasing of fertility will lead to the imbalance in the demographic structures. This chapter also discusses the actions taken around the world during the pension re-

forms.

2.1 Introduction

Almost all the countries have pension systems to protect elder people from poverty in their later life (Edward, 2007). The retired people account for a substantial share of the total population, and these proportions are continually growing[4]. For example, the share of individuals aged 60 and over has increased from 8% of the total world population in 1950 to 12.3% by 2015, and it is projected to reach 25.9% in 2080 (United Nations, 2015). For most of these elderly people, the pension benefits constitute the main source for their incomes after retirement. Furthermore, the safety of a pension system is important to a country's public finance. According to OECD (2015), the public pension expenditures account for 18% of total public spending across OECD (Organisation for Economic Co-operation and Development) countries, and it represents 9% of the total GDP. The deficits in a pension system might lead to the increase of a country's total public expenditures and hence raise the government debt, which in turn influence the global economy as a whole. The projections from OECD (2015) show that pension expenditures in the vast majority of the countries will keep increasing in the proportion of their GDPs until 2050[5]. Thus, the Green Paper and the White Paper (European Commission, 2010, 2012) have encouraged the European countries to

[4]The share of elderly people in the percentage of total population in the world is presented in Appendix A.

[5]The public expenditure on pensions in the percentage of GDP in the world from 2010 to 2050 is shown in Appendix B.

consolidate a solidary and safety pension system in the Europe, and OECD also put the reforms of pension systems among their member and partner countries on the agenda (OECD, 2015, 2016b). The pension reforms around the world aim to achieve a more financially sustainable PAYG pension system, which could also provide the adequate incomes for individuals in their old age.

China, as a partner of OECD and a member of Group of Twenty (G20), is one of the largest economies in the world. The pension reforms in China have drawn much attention around the world recently, because the country's economy is growing fast, and accounts for more shares in the world. The adequacy and sustainability of the Chinese pension system are meaningful to the world. The projected change in pension expenditures (% of GDP) in China will increase by 5.8% until 2050, while the change is only 1.1% for the average level of OECD countries (see Table B.1 in Appendix B). In turn, to better analyse the pension system in China, it is necessary to give an overview of the pension systems and the pension reforms in a global context.

The later contents in this chapter are organised as the following. Section 2.2 presents some basic concepts in the pension system and gives some examples in a global context. This section also explains the main objectives for a pension system, in order to help readers better understand the recent pension reforms taken around the world. Following that, Section 2.3 describes the pension reforms which have been taken recently around the world. Finally, Section 2.4 concludes the chapter.

2.2 Pension Schemes and Objectives

2.2.1 Pension Schemes

A Pension is the income people can receive after their retirement to replace the earnings from employment (OECD, 2015). A pension is needed because people's capacity to work and their ability to earn the income decline in later life. Germany was the first country who introduced a public pension system in 1889, then followed by, Denmark in 1891, Britain in 1908, Australia in 1909, and America in 1935 (Sullivan, 2004). The coverage of the pension system in the past was usually very narrow, it only provided benefits to the elderly people whose incomes after retirement were relatively low, and mainly aimed to prevent poverty in the whole society. However, nowadays a lot of countries in the world have been able to set up the pension systems to cover a broader range of people with the objective to secure a decent living standard after their retirement (Blackburn, 2003; Edward, 2007). Except from pensions, people might also have other sources of income after their retirements, such as income from properties, savings and financial investments, or even financial support from their family members. However, the difference between a pension and other incomes is that pensions provide a stream of regular payments guaranteed for their later life. The mechanisms to provide retired people with regular incomes or allow those people of working-age to be engaged in their future incomes after their retirements are called pension schemes (European Commission, 2015a). Without pension schemes, the only way that workers can finance their consumption after retirement is to save money during the period of

employment. Due to the uncertainty of life expectancy, it is difficult for the workers to decide how much should be saved for the future (Gillion, 2000). Some of them would over save to avoid the exhausting of savings before they die. On the contrary, the others would not save enough for their later life. Pension schemes could overcome this shortage by linking retirement benefit in return for contributions made during the working years.

Defined-Benefit (DB) and Defined-Contribution (DC)

Pension schemes can be classified into two types (Bodie et al., 1988): defined benefit (DB) and defined contribution (DC). Under a DC scheme, each employee has an account into which they make regular contributions, and pension is dependent on the amount of money they contributed and the return of the accumulation in the account (Kruse, 1995; Ippolito, 1995; Choi et al., 2002). In a DB scheme, the pension benefit is determined by a formula which takes into account the number of contribution years and the participant's wages or salary (Harrison and Sharpe, 1983; Exley et al., 1997). Almost every country chose DB scheme at the establishment of their pension systems and most of them keep the form till now (see Table 2.1), because the redistribution of the contributions is easier to be controlled by the government under a DB scheme. While the contributions are directly linked with benefits under a DC scheme, and redistribution of the welfare among elder people in the whole society is relatively difficult to be attained (Sullivan, 2004). According to Bodie et al. (1988) and Poterba et al. (2007), the pension benefit is defined in a DB scheme. The amount of pension from DB schemes is predetermined by the certain benefit formulae, while the contributions

are variable. Contribution levels could be changed by authorities under DB schemes to meet the financing requirements. Thus, DB schemes provide fixed benefits based on variable contributions. On the contrary, the amount of contribution is defined under a DC scheme. DC schemes provide variable pensions based upon fixed contributions. Because the rule of DC schemes regulates the amount that must be contributed into the scheme, but not the pension benefit that will be paid out.

Pay-as-you-go (PAYG) and Funded

Either DB or DC schemes could be financed in pay-as-you-go (PAYG) plan or funded plan (Bodie et al., 1988). The PAYG DC is the so-called notional defined contribution (NDC) scheme (Cichon, 1999; Holzmann et al., 2006). In a PAYG plan, contributions made by the current workers are paid out immediately as pension benefits to the pensioners. Each generation pays the pensions for the preceding generation (Breyer, 1989; Brunner, 1994). Technically, there should not be any storage of fund in the PAYG plan[6]. In a funded pension plan, contributions are paid into an account and accumulate and earn interest at a certain rate (Sullivan, 2004). In this plan, each generation provides their own incomes, which is independent of preceding or following generations (Feldstein and Liebman, 2002). In other words, pensions for current retirees are paid by current active workers under a PAYG plan, whereas current workers finance their own pensions in a funded plan. Because PAYG plans finance pension benefits from the contribution of current workers, they can begin paying the pension at the beginning of the establishment of the system. On the contrary, a disadvantage of the funded

[6]In practice, there may be a buffer fund in the PAYG plan. The buffer fund is generated by the cash surplus during a period and is reserved to pay for the cash deficits for the uncertainty in the future.

plans is that it has to wait many years from the time the system is set up before enough funds can be provided to pay for the pension benefits (Siebert et al., 1997). Thus, the vast majority of countries choose the PAYG plan at the beginning period of their pension system and keep this form of pension system till now (see Table 2.1). However, risks do exist during the operation of a PAYG plan (Mylonas and Maisonneuve, 1999). Since in a PAYG plan, the benefits that current pensioners receive rely on the promise of the following generations to pay them the pensions until death. Thus the main risk exists in a PAYG pension plan is arising from the change in the ratio between contributions and pensions, which is determined by the relative size of the two generations. Demographic risk emerges when the population is shrinking in a PAYG plan. While in a funded pension plan, the main risks are the investment risks (such as the change of interest rate and inflation rate) and the challenge for the increasing of life expectancy (Kaganovich and Zilcha, 2012). At the time of retirement, the funds in a funded plan will transfer into a life-long annuity. The initial annuity payment is calculated according to the life expectancy at that time, but pension in payment is not adjusted to the future changes in life expectancy.

Table 2.1 shows the current type of the pension systems for some major economies around the world. We can see, the vast majority of the countries have the PAYG DB schemes in their current public pension system. The exceptions, who have the NDC or Funded DC schemes now, all had the PAYG DB scheme before, and recently transferred to other schemes through pension structure reforms. A transition from DB to DC could shift the risk from the government to individuals, because in a DB scheme the

benefit formula is predetermined by the government, while in a DC scheme the individuals take the main responsibility for their pension benefit. Thus, countries, such as Chile, Sweden, Italy and so on, have reformed their pension structures to DC schemes. Transitions to funded DC scheme might encourage participants to join the pension system and pay the contributions on time. However, it also brings about some problems (Holzmann, 2013). For example, the funded plan will enlarge the impact of investment risks on the pension fund, and requires more administration costs for the management of the pension fund. Alternatively, the transition to NDC still cannot solve the current problem facing by PAYG scheme in the context of global ageing. Thus countries are prudent with the structural reforms, since it will lead to additional administration costs and a big impact on the current system (Holzmann et al., 2006, 2012). China has introduced an individual account in the form of DC scheme in 1995, the scheme is designed to be a funded plan in order to increase the labour mobility at that time (Details for the individual accounts and its evolution are described in Chapter 3). So, current pension schemes in China consists of two parts, PAYG DB and funded DC as shown in Table 2.1. Besides a structural reform, a lot of the countries have conducted various parametric reforms recently. Details about the pension reforms around the world are described in Section 2.3.

Table 2.1: Current type of the mandatory public pension systems

	PAYG DB	Funded DB	NDC	Funded DC
OECD members				
Australia	✓			
Austria	✓			
Belgium	✓			
Canada	✓			
Chile				✓
Czech Republic	✓			
Denmark	✓			
Estonia	✓			
Finland	✓			
France	✓			
Germany	✓			
Greece	✓			
Hungary	✓			
Iceland	✓			
Ireland	✓			
Israel	✓			
Italy			✓	
Japan	✓			
Korea	✓			
Luxembourg	✓			
Mexico				✓
Netherlands	✓			
New Zealand	✓			
Norway			✓	
Poland			✓	
Portugal	✓			
Slovak Republic	✓			
Slovenia	✓			
Spain	✓			
Sweden			✓	
Switzerland	✓			
Turkey	✓			
United Kingdom	✓			
United States	✓			
Other major economies				
Argentina	✓			
Brazil	✓			
China	✓		✓	
India	✓			
Indonesia				✓
Russian Federation			✓	
Saudi Arabia	✓			
South Africa				✓

Own source based on OECD (2015) and OECD country profiles.

Pension Tiers – Traditional Three-Tier and World Bank Five-Tier

Pensions could also be classified by the different levels of organisers. In this case, a pension system could fall into different tiers, namely public pension, occupational pension, and personal pension (Sullivan, 2004; European Commission, 2015a).

The first tier is the public pension (Chand and Jaeger, 1996; Impavido, 2002), also known as state pension, which are organised and operated by governments. They aim to prevent poverty among the old-age population and to ensure that the workers' income are maintained after their retirement by linking the value of pension benefits to earnings from employment. The vast majority of public pension schemes are operated based on a PAYG DB plan, thus the cost of providing the pensions for retired workers is met from the contributions of current workers in employment. In other words, public pension schemes work in the way that redistributing income directly from workers to pensioners. In addition, those workers currently in employment are willing to pay the pensions for preceding generations based on the understanding that the next generation will pay their pensions in the future.

The second tier is the occupational pension (Hannah, 1986; Sharpe and Treynor, 1977), also known as company pension. It is organised and operated by an employer to provide pension benefits for its employees. It can be either set up as a trust fund running by trustees or entrusted to a life insurance company. The contribution to this scheme is usually from employees as well as their employer. It works like a welfare from employer to benefit their employees, because the pensions paid out are usually tax-

exempted. Occupational pension schemes are usually funded, and it can be either DB or DC type.

The third tier is the private pension (Munnell, 1982; Shah, 1999), also called personal pension. A private pension is one way that individuals can choose to save for their retirement by investing in a pension plan from an insurance company. Private pensions can only be operated under a funded DC scheme.

This thesis focus on the analysis of the first tier, i.e. public pensions, because it is the basis of a country's old-age social security and is usually mandatory. The second and third tiers are supplements for the first-tier.

The World Bank has also introduced a five-tiers diversified classification for the pension system, based on the needs of target populations (Holzmann et al., 2008). The five tiers are stated as below:

1. A non-contributory 'zero tier' extending some level of old-age income security to all of the elderly. This tire is designed to be financed by local or national governments. The objective of this tire is to alleviate poverty in order to provide all the elder people with a minimal level of protection. It ensures that people with low earnings during the employment or who has shorter career can be provided with basic protection.

2. An appropriately sized mandatory 'first tier' with the objective of replacing some

portion of lifetime pre-retirement income through contributions linked to earnings. This tier secure the decent living standards for elderly people and protect them from inappropriate planning due to the uncertainty of life expectancy and unforeseeable risks of financial markets. It is typically financed by a PAYG plan, thus it is subject to demographic risks.

3. A mandatory funded DC 'second tier' that typically provides privately-managed individual savings accounts with independent investment management. It provides a wide range of options. People are free to choose investment portfolios and investment managers, as well as the option for the withdrawal phase. Compared to DB plan, this tier face more financial and agency risks due to the private pension management. As mentioned before, it also subjects to the risk of the high transaction and administration costs, and the longevity risks existing in the DC plan as well.

4. A voluntary funded 'third tier', it can follow various types and take kinds of forms. It could be employer-sponsored occupational pensions or individual savings as private pensions. The designed structure of this tier is relatively flexible in nature. This tier compensates for the rigidities in the design of other tiers stated before. However, it faces the similar risks as discussed in the second tier.

5. A 'fourth tier' can be either in the form of informal support, such as family support or incomes from property investment or in the form of formal social programs, such as health care or housing. The necessity of this tier is dependent

on the design and implementation of other tiers.

The World Bank's five-tier classification is different from the traditional three-tier classification. It is more like a recommendation for the future reforms than a classification of the current pension systems in the world. The five-tier model addresses the importance of private pensions compared to the traditional three-tier model and designs it as mandatory in a pension system. While in the traditional three-tier model, the private pensions and occupational pensions are usually voluntary to participate. It also encourages governments to set up a non-contributory tier to prevent poverty among the elderly people and addresses the need for informal support to supplement the original pensions. In the sense of the World Bank's five-tier model, this thesis focus on the analysis of the mandatory 'first tier'.

2.2.2 Pension Objectives

The original design of pension schemes or the following pension reforms both aim to achieve the two principal objectives: adequacy and sustainability (European Commission, 2010; OECD, 2015, 2016b). The purpose of adequacy is to prevent poverty among the elderly and secure a decent standard of living after their retirement (European Commission, 2010). It means people who are participating in the labour market should have the opportunity to build up sufficient pension provisions during their working life by contributing to pension schemes. Pension systems should be set up in order to enable individuals to maintain their living standards after retirement. A paramount

objective of a pension system is to achieve the sustainability (European Commission, 2010), which means the contributions could afford the expenditures in the long term. Moreover, financial sustainability has drawn much attention recently in the current global context of rapid ageing. Adequacy and sustainability are two sides of a coin. If a pension system is inadequate, it will face the risk of the increases in pensions or higher demand for other benefits in future, which will lead to the unsustainability. Equally, if a pension system is unsustainable, it must be inadequate in the long term. A pension system which is financially bankrupted could not afford to pay the pension benefits, not even mention to secure the decent living standards of its participants. Thus, the recent pension reforms are striving to deliver adequate retirement incomes to the elderly people while retaining the financial sustainability of the system at the same time (OECD, 2015). More detailed explanations for these two principal objectives are presented in the following.

Pension Adequacy

Adequacy has two dimensions, intrageneration adequacy and intergeneration adequacy (Sullivan, 2004). Intragenerational adequacy requires a just distribution of resources among the individuals in the same generation, while intergenerational adequacy relates to the adequate distributions between the different generations.

There are also two directions in the pursuit of intragenerational adequacy, i.e. horizontal adequacy and vertical adequacy (European Commission, 2015b). Horizontal adequacy requires that individuals who have paid the same total contributions during

their working times should receive the same pension benefits after their retirement. In other words, people who are in the same circumstances should be treated similarly. The vertical adequacy requires the redistribution of the income from contribution according to each individual's need. It means the income redistribution is operated based on social solidarity. Since the individuals' needs are difficult to measure, the principle of the vertical adequacy mainly aims to prevent poverty. The horizontal and vertical adequacies are naturally conflicting, however, both of them could be pursued gradually at the same time with the aim to build up a sustainable pension system in a broader sense.

The concept of intergenerational adequacy has drawn much attention recently. The topic becomes extremely hot in the context of sustainability discussion and the emerging demographic ageing problem around the world (European Commission, 2015a). Intergenerational adequacy could be achieved if the future generations have the opportunity to live at a comparable or better standard of living as the preceding generations (Mattil, 2006). Currently, the major concern in this area is how to adequately share the financial burden of demographic ageing among all the generations participating in the pension system. The evaluation in this area requires the analysis in the aspects of demographic changes and actuarial calculations.

The measures could be taken to improve the pension adequacy is described as below:

- Increase the coverage of public pension system and enhance the development of

voluntary occupational or private pension schemes.

- Award retroactive pension credits or reduced the impact of missing years of contributions on pension benefits. As mentioned before, pension benefits are dependent on the number of contribution years. Thus, the way to record the contribution periods affects the level of pension benefits. This measure also helps to increase the fairness of pension received between men and women, since women tend to have more breaks during their contribution periods due to family affairs.

- Reduce the taxation on pensionable incomes or pension entitlements.

- Lower the management costs and improve the security of the pension system.

- Improve the security in pension fund through diversification of the investment portfolios.

According to OECD (2015), there are a lot of countries who have already taken the above measures to improve the pension adequacy. Japan has decreased its requirement for contribution years. While the United Kingdom and Canada have enhanced their complementary pension schemes by auto-enrolment and creation of new schemes respectively. Increasing pension benefits to the retirees is the direct way to improve pension adequacy. Some countries, such as Canada, France and Japan, have changed the ways to calculate pension credits in order to increase pension benefits. While countries including Poland, the United Kingdom, Japan and Sweden, have directly in-

creased the adequacy by lowering the taxation on pension withdrawals or increased the pensionable incomes by reducing the taxation on it. Efficient data collection system and transparent information disclosure process could reduce the management costs, and ensure the pension entitlements could be better understood and achieved by the participants. Countries, like Australia, France, New Zealand, and the United Kingdom have already made effort on it by providing easier access to pension information. As mentioned before, both PAYG and funded scheme have the pension fund to reserve accumulations for future uncertainty (In a PAYG scheme, the pension fund is called buffer fund). Thus, the security of pension fund is important to a country's pension system as well as the ability to provide adequate pensions. A lot of countries including Chile and Italy have started to diversify the investment portfolio in the pension fund. Details of the pension reforms in different countries regarding the improvement of pension adequacy are presented in Section 2.3.

Pension Sustainability

The concept of sustainability was first introduced in the area of environmental studies. The environmental economists stated that the living generations should not employ more renewable natural resources than they can regenerate, and nonrenewable resources should only be used if technologies allow substituting the respective natural resources in the future (Pearce, 1992). The Brundtland Commission et al. (1987) defined the sustainable development as which will not compromise the ability of future generations to meet their own needs in current times.

It was in the early 1990s that the concept of sustainability was applied to public finance in the context of worldwide ageing (Holzmann et al., 2012). Sustainability regarding the pension system can be defined in a narrow or a broad sense. In the narrow sense, sustainability is related to the achievement of the financial equilibrium of the pension system in the long-term. The World Bank defined a sustainable system as the one that is financially sound and can be maintained over a foreseeable horizon under a broad set of reasonable assumptions (Holzmann et al., 2008). European Commission defined the fiscal sustainability as the long-term ability of the government to meet the financial obligations linked with its current and future expenditures and debts (European Commission, 2015b). No matter by which definition, the analysis requires the calculations of total pension expenditures and total pension incomes from contributions. Some countries, such as United States, Canada, Finland, Germany and the United Kingdom, use aggregate accounting methods to analyse the sustainability of their pension systems (Boado-Penas and Vidal-Meliá, 2012). This measure involves projections for future demographic and economic changes and calculates the difference between the aggregate spending for pension benefits with incomes from contributions in the long term. The other method to measure the sustainability is based on verifiable facts, it analyses the liabilities and assets in the current pension system regarding the current participants and economic context. Sweden has used this method to compile their annual report since 2001, and some researchers in Japan and Spain have used this method to analyse the pension systems in their countries (Boado-Penas et al., 2008; Takayama, 2005). Detailed explanations for the methodologies to analyse the financial sustainabilities are included in Chapter 3.

However, not only the financial problems in the pension system may lead to a breakdown, but also the lack of credibility of the participants and related political decisions, which is denominated as the sustainability in a broader sense. For example, if members of the working-age population do not believe that the current pension system could provide their adequate pensions in the future, they will try to avoid participating in the system by leaving the labour market or creating forms of employment that do not require participation in the pension system. Another example is, the policies regarding the fertilities and migrations will influence the demographic structure in a society, and this, in turn, will affect the total pension income and expenditure in a system. Sustainability in the broader sense comprises such non-monetary aspects of systemic stability as stated before. Furthermore, the sustainability in a narrow sense interferes with the associated social and political sustainable factors in a broader sense.

The measures which could provide the direct improvement of the financial sustainability are presented as below:

- The most common measure is to increase the statutory retirement age, because it can lengthen the contribution periods and delay the time to claim pension entitlements.

- Change of the indexation of pensions to give a less generous plan is another way to decrease pension in payment. Decreasing pension benefits could directly reduce the pension in payment, and hence decreases the expenditures on pensions.

- Raising contribution rates could increase the incomes from contributions.

- Reducing management and administration costs in the pension system, as stated before in the measures to improve pension adequacy, is also helpful to achieve financial sustainability in the long term.

According to OECD (2015), many countries have already taken the above measures in order to achieve the financial sustainability in the long term. Almost all of the countries in OECD have scheduled to gradually increase the statutory retirement age. At the same time, some countries have managed to reduce the pension benefit at a reasonable level or decrease the indexation rules on pensions. For example, countries, such as Finland, Greece, Belgium and the Slovak Republic have set a fixed amount for their pension indexation. While Spain and Luxembourg have planned to link the pension indexation with future expenditures. Some countries such as Canada and France have successfully increased the incomes from contributions by raising the contribution rates. Details of the pension reforms in different countries in the aspect of financial sustainability are presented in Section 2.3.

It should be noted that the measures to improve pension adequacy and financial sustainability are not completely separate. Just as we have mentioned before, pension adequacy and financial sustainability are the two sides of a coin. Actually, the improvement of one side is usually helpful to enhance the other side.

2.3 Pension Reforms Around the World

The following contents in this chapter describe the global trend of pension reforms in the context of worldwide ageing and address the necessity for the pension reforms in China in the current situation. The reforms presented here take into account two principal objectives in the pension system, i.e. pension adequacy and financial sustainability.

Reforms regarding Pension Adequacy

According to OECD (2015) country profiles, a lot of countries have made efforts to improve the pension adequacy. The detailed measures taken by each country are stated as below:

In Japan, from April 2017 the required contribution years to get the national pension will decrease from 25 to 10 years (Ministry of Health, Labour and Welfare, 2015). It thus can increase the coverage and benefit more workers who have a short career. Countries, such as Canada, Ireland, the United Kingdom and the United States, who had the long history of complementary occupational pensions and private pensions, also made some development to broaden the coverage (Hofäcker et al., 2016). In the United Kingdom, the auto-enrolment of the occupational pension has been conducted gradually. Large employers must automatically enrol workers since October 2012 and medium-size employers since April 2014, while small employers should comply the enrollment from January 2016 (Department for Work and Pensions, 2014). Canada has created new schemes to encourage participation in voluntary private pensions (Minis-

ter of Finance, 2012).

Canada has also improved the way to record contribution periods. In Canada, past earnings are ranked in decreasing orders and periods with lower earnings are dropped off during the calculation of pension benefits. In 2014, the share of the dropped off periods have increased from 16% to 17% (Government of Canada, 2015). France has changed to a more generous plan for the pension accrual during the time of maternity leave, professional training and unemployment (European Union, 2015). In Japan, it will be possible for workers to pay additional voluntary contributions in order to make up gaps during their contribution periods (Ministry of Health, Labour and Welfare, 2015).

Poland has decreased taxation on pensions by introducing a new tax incentive on pensionable incomes to encourage people to participate in the voluntary private pensions (Chłoń-Domińczak, 2016). In the United Kingdom, the tax on withdrawals has been lowered and the tax-free amount for lump sum payment has been increased in 2015 (Department for Work and Pensions, 2014; European Union, 2015). In Japan, women on maternity leave have got tax exempt from employees' pension contributions since April 2014 (Kitao, 2016). The basic pension income tax deduction in Sweden for people over age 65 has been increased in 2014 (European Union, 2015; Swedish Pensions Agency, 2015).

Australia has completed the SuperStream project who aims to establish a mandatory,

uniform e-commerce standards to manage contributions in retirement contingency and regulates the transfers between funds in 2016 (Ingles, 2014). France has begun to set up the electronic account for every worker in 2016. The account will provide the information, such as their past contributions, and projected pension benefits in both public and mandatory occupational systems (European Commission, 2015b). New Zealand requires the pension providers to post their information on fund performance, fees, returns and key staff information quarterly. Furthermore, the providers also have to offer financial education and advice to pension account holders (European Commission, 2015a). The same case is regulated in the United Kingdom, while the pension providers must offer their members free face-to-face advice on pensions (European Union, 2015).

Some countries have begun to improve the investment portfolios in their pension funds. According to OECD (2016a), Chile has taken the measure to improve the safety of its pension fund by introducing the maximum limit for foreign currency hedges, while Italy has gone through a new rule to introduce the diversified portfolios in order to secure the more prudent investments.

Reforms regarding Financial Sustainability

In the aspect of sustainability, as we have mentioned before, the reforms could be parametric reforms or structural reforms. Parametric reforms directly target the financial balance in a pension system, thus a lot of countries have already conducted such reforms (European Commission, 2012).

The statutory retirement age is the age regulated by the government at which people can get retired and be eligible for their pension benefits (OECD, 2015). Adjustment of retirement age is an efficient and most common method during the pension reforms, since it affects both the contribution years that workers would contribute into the system and the pension benefits that pensioners would receive in the future.

In Table 2.2, we can see the current statutory retirement ages in some major economies vary a lot, from 55 years old in Indonesia to 67 years old in Iceland and Norway. The average age is 64.7 years old for men and 63.5 years old for women around the OECD countries. The statutory retirement age in China is relatively low in the world, which is 60 for men, 50 for female workers and 55 for female managers. It is because the statutory retirement age has not been changed since it has been first regulated in 1997 (Information on the pension system in China is presented in Chapter 3).

Furthermore, a lot of countries will increase the statutory retirement ages in the future. The statutory retirement age in Italy will increase from current 66.3 years for men and 62.3 years for women to 67 years for both genders in 2021 (Belloni and Maccheroni, 2013). In Poland, the retirement age will be increased from 65 and 60 years for men and women respectively, to 67 for both but in 2020 for men and in 2040 for women (Góra, 2013). The retirement age for women in the United Kingdom will converge to 65 as the same with men in 2018, while the current retirement age for women is 62 years old. Further increases for both genders will be 66 in 2026 and 67 by 2028

(Department for Work and Pensions, 2014). Governments in Belgium has decided to increase the retirement age to 67 by 2030 (Struyven and Pollet, 2015). Canada will increase its statutory retirement age for the basic pension to 65 and 67 between 2023 and 2029 (Minister of Finance, 2012). Retirement age in Ireland has already raised from 65 to 66 in 2014, and will further increase to 67 by 2021 and to 68 after 2028 (Government of Ireland, 2011). Germany will gradually increase the retirement age by one month a year from the current level of 65.3 years, and four months for the cohort born in 1950 to attain the target age of 67 in the future (Tao, 2017). In Hungary, the retirement age will increase from 62.5 currently to 65 in the future (Jarocinska et al., 2014). The retirement age has been raised from 65 to 66 years old in Portugal and is currently planning to be linked with the change in life expectancy (Reis, 2015). Netherlands has also scheduled to increase the retirement age for the basic pension to 66 by 2018 and 67 by 2021 (Sonnet et al., 2014). The retirement age will be raised in Spain from 65 in 2013 to 67 in 2027. However, full pension benefits will still be available at age 65 for those whose contribution years is equal to or above 38.5 years (De La Fuente and Domenech, 2013). Australia made a decision to gradually increase its retirement age in 2012, the retirement age was planned to reach 65 in 2017 and 67 in 2023. A further increase to 70 in 2035 is currently under consideration (Podger et al., 2014). While in France, the minimum contribution years will be increased by 1.5 years in 2035 from the current level of 41.5 years (Hassenteufel and Palier, 2015).

Pensions in payment are adjusted during retirement to reflect changes in costs, and to secure the decent standards of living for older people over time. The reason for this

Table 2.2: Current statutory retirement ages for public pensions

	Men	Women		Men	Women
OECD members			**OECD members (cont.)**		
Australia	65.0	65.0	Norway	67.0	67.0
Austria	65.0	60.0	Poland	65.0	60.0
Belgium	65.0	65.0	Portugal	66.0	66.0
Canada	65.0	65.0	Slovak Republic	62.0	62.0
Chile	65.0	60.0	Slovenia	65.0	65.0
Czech Republic	62.7	61.3	Spain	65.2	65.2
Denmark	65.0	65.0	Sweden	65.0	65.0
Estonia	63.0	61.0	Switzerland	65.0	64.0
Finland	65.0	65.0	Turkey	60.0	58.0
France	61.2	61.2	United Kingdom	65.0	62.0
Germany	65.3	65.3	United States	65.0	65.0
Greece	65.0	65.0			
Hungary	62.5	62.5	OECD average	64.7	63.5
Iceland	67.0	67.0			
Ireland	66.0	66.0	**Other major economies**		
Israel	67.0	62.0	Argentina	65.0	60.0
Italy	66.3	62.3	Brazil	65.0	60.0
Japan	65.0	65.0	China	60.0	50.0
Korea	65.0	65.0	India	58.0	58.0
Luxembourg	65.0	65.0	Indonesia	55.0	55.0
Mexico	65.0	65.0	Russian Federation	60.0	55.0
Netherlands	65.2	65.2	Saudi Arabia	60.0	55.0
New Zealand	65.0	65.0	South Africa	60.0	60.0

Own source based on OECD (2015) and OECD country profiles.

adjustment is to protect older people from inflation (OECD, 2015). It also has a powerful impact on the value of entitlements, thus can be also used as a method of pension reforms to reduce the total pension expenditures.

Few countries had indexation rules when their pension systems were first established (Sullivan, 2004). However, the high-inflation period in the 1970s led some countries to adopt procedures for adjustment of pension in payment. Thereafter, many of them moved from earnings related to price related indexation from the 1980s to 1990s, because wages tend to grow faster than prices (Weaver, 1998). Some countries have set up the indexation policies, which automatically adjust the targeted indexation of pension entitlements on an annual basis based on some indexes (OECD, 2015). Countries including Canada, Chile and Sweden adjust their pensions based on the prices (Government of Canada, 2015; Mesa-Lago and Bertranou, 2016; Swedish Pensions Agency, 2015). Other countries, such as Denmark, Norway and so on, change their pension benefits according to the wages (Hagist et al., 2014). Another example is the United Kingdom, where pensions are indexed on whatever is the highest: annual changes in earnings, in prices, or a rate of 2.5% (Department for Work and Pensions, 2014). Pensions in Japan are indexed to wages until an individual reaches age 67 and then to prices afterwards (Ministry of Health, Labour and Welfare, 2015). China does not have any fixed indexation policy currently, but the pension in payment is adjusted annually by the national government to keep the living standards for the current pensioners.

The recent reforms regarding the decreasing of pension benefits are stated as follows. Spain will adjust the initial pension to new retirees based on the change in life expectancy since 2019 in every five years (Vidal-Melia, 2014). Finland has decreased its earnings-related indexation on pensions from 1% to 0.4% in 2014 (Jarocinska et al., 2014). Pension indexation has been frozen since 2011 in Greece and 2015 in Belgium (European Commission, 2015a; Struyven and Pollet, 2015). Italy has set a maximum limit to prevent the high growth of pensions, when pension goes above a threshold, the indexation will be equal to a fixed amount (Belloni and Maccheroni, 2013). While pension benefit has been increased by a fixed amount between 2013 to 2017 in the Slovak Republic (Sika and Martišková, 2016). Furthermore, some countries have planned to link the indexation on pensions with the financial status of the pension system. It is also in Spain that indexation will be adjusted on an annual basis depending on the ratio of contributions and expenditures in the pension system (European Commission, 2015a). In Luxembourg, a 'reduction factor' has been introduced in 2013, it regulated that pension would only increase if the annual income from contributions exceeds expenditures on pension payments (Kerschen, 2016).

The contribution rate is the ratio of pensionable earnings that current workers need to contribute into the system during their employment in order to achieve their pension entitlements in the future (OECD, 2015). It has an impact on the income from contributions in a pension system. Thus, it is often used in a pension reform to adjust the amount of incomes.

Table 2.3 presents the current contribution rates in nine countries including China. The selected countries are whose pension system is operated separately with other social security systems, such as health insurance, disability insurance and so on. Thus, the contributions are more linked with pension benefits in these countries. Contributions are usually made from both employees and employers in the public pension system, however, there are some exceptions. For example, the contributions are solely made by employers in Australia and Iceland, and only employees contribute to their pensions in Netherlands. Table 2.3 shows that the total contribution rates vary from 1.36% in Denmark to 33% in Italy and the average rate is equal to 15.06% around the other eight countries excluding China. The total contribution rate in China is 28%, and it compromises of 8% from employees and 20% from employers. The contribution rate in China is relatively higher than in other countries (Zhang, 2016), and it has been raised from 3% when the pension system has been first established in China (Please refer to Chapter 3 for detailed evolution in the Chinese pension system). In the future, Canada will increase its contribution rates from current 9.9% to 10.8% from 2017 (Government of Canada, 2015). While in France, the contribution rate will be increased by 0.3% since 2017 for both employees and employers (Hassenteufel and Palier, 2015).

Replacement rate is the comparison between the income levels of elderly people after their retirement in relation to pre-retirement earnings (OECD, 2015). It is an appropriate measurement for evaluating the ability of a pension system to maintain the individuals' living standards after retirement. In other words, it also shows to what extent pension systems aim to preserve the individual's standard of living moving from

Table 2.3: Contribution rates for mandatory public pension system.

	Employee	Employer	Total
Australia		9.50	9.50
Belgium	7.50	8.86	16.36
Canada	4.95	4.95	9.90
Denmark	0.54	0.82	1.36
Finland	7.05	17.75	24.80
France	6.80	8.45	15.25
Germany	9.45	9.45	18.90
Iceland		7.79	7.79
Israel	3.75	3.75	7.50
Italy	9.19	23.81	33.00
Japan	8.74	8.74	17.47
Korea	4.50	4.50	9.00
Luxembourg	8.00	8.00	16.00
Netherlands	17.90		17.90
Poland	9.76	9.76	19.52
Sweden	7.00	11.38	18.38
Switzerland	4.20	4.20	8.40
Turkey	9.00	11.00	20.00
Average			15.06
China	8.00	20.00	28.00

Own source based on OECD (2015) and OECD country profiles.

employment into retirement. It is expressed in the way that pension entitlements as a share of individual lifetime-average earnings (Edward, 2007). The replacement rate could be used as an indicator for the insurance role of a pension system. Some countries lower their target replacement rates in order to reduce the pension expenditures. For example, Korea has decreased the replacement rate for the retirement contingency from 60% to 50% in order to reduce the pension payments, and this is currently scheduled to decrease further to 40% by 2028 (Moon, 2009)

OECD has calculated a projected replacement rate for major economies around the world (OECD, 2015). The calculation based on the assumption that the participant en-

ters the system in 2014 at age 20 and retires once reaching the statutory retirement age. The result shows that the replacement rate in China is equal to 74%, which is higher than the average around OECD countries (52.7%). The high replacement rate in China indicates that the amount of pension benefits is relatively high in China compared to its individual earnings (Liao, 2016).

Furthermore, some countries, such as Sweden, Germany, and Japan, have set up an ABM to adjust the pension parameters automatically based on some indicators that reflect the financial health of the pension system (Vidal-Meliá et al., 2009, 2010; OECD, 2012).

Alternatively, as we have mentioned before, a transfer from DB to DC could shift the risk from the government to individuals, because DC scheme provides a clear and straightforward link between contributions and benefits. Thus, some countries have undertaken some structural reforms to transfer from original PAYG DB scheme to NDC or funded DC schemes. Countries, such as Sweden, Poland, Italy, and Latvia have undertaken some structural reforms by changing the formula used to calculate their initial pension from a DB to an NDC scheme (Holzmann et al., 2012; Vidal-Meliá et al., 2010), or even to a fully funded scheme, as in the case of Chile. While Korea is considering changing to an NDC scheme and setting up an ABM (Bonnet et al., 2010), and India is planning to change to a funded DC system (Bali, 2014).

In China, the ageing problem is quite severe (Dorfman et al., 2013). The fertility rates

have decreased from 6.11 in the 1950s to 1.55 in the 2010s, and it leads to a decrease in the number of contributors financing each pensioner from 13.2 in the 1980s to a projected 1.6 in the 2080s, according to United Nations (2015). China has tried to solve the problem by decreasing the replacement rates in urban areas from 77% to 45% in the last decade (OECD, 2010b), and is currently considering increasing the statutory retirement age from 50 (women) and 60 (men) to 65 in both cases (Wang, 2016; Zhang and Guo, 2015). At the same time, China has introduced longevity insurance annuities to maintain the living standard of elder people (Chen and Turner, 2014). Finally, Oksanen (2010), Dorfman et al. (2013) and Zheng (2014) have recommended China to consider transferring its pension scheme to NDC.

Recommendations for Future Reforms

OECD (OECD, 2015) as well as White Paper (European Commission, 2012) have addressed the recommendations with the objective to achieve a sustainable pension system which also delivers adequate retirement incomes in the current context. The contents of the recommendations are listed as below:

- Link the parametric reforms with ABM, in order to respond to the context of rapid ageing more efficiently;

- The access to early retirement and other early exit pathways should be restricted or eliminated, because the older workers who are laid off still often enter into early retirement programmes;

- Support longer working periods by providing access to life-long learning, and develop employment opportunities for older workers and supporting active and healthy ageing;

- Support the development of supplementary pension tiers to enhance retirement incomes. Private pension systems, who usually take the forms of funded DC, face risks in the current context of low interest rates. Diversity the sources of financing retirement is needed;

- Rebuilding the trust among the participants in the pension system is demanding. Better information and increased transparency of the current pension system could be delivered by providing annual pension report.

2.4 Summary

The pension system, with the objective of protecting elder people from poverty and securing a decent life after their retirement, is necessary to a country's social security insurance system. Since the pension expenditures account for the government's public expenses, the safety of a pension system is also important to a country's financial security. Furthermore, with the trend of increasing globalization, each country's financing plan could influence the global economy as a whole. Thus, a lot of international organizations have put pension reforms on their agendas, with the aim to achieve the adequate and sustainable pension systems in a global context (European Commission,

2010, 2012; OECD, 2015, 2016b).

This chapter describes the pension systems around the world as well as the case in China, and then discuss the pension reforms in a global context. Almost every country start their initial pension systems in the form of PAYG DB, because this kind of system can immediately start to finance the pension payments at the establishment of the system and is easy for the redistribution of the welfare by the government. The PAYG pension system works in the way that current active workers pay the pension benefits to current retirees. However, the recent trend of global ageing has led to the increasing imbalance between the number of working-age population and retirees, which raises serious concerns in this system. Thus, a lot of countries has conducted some parametric pension reforms, such as, increasing the contribution rates and retirement ages, or decreasing the indexation on pensions and replacement rates. Some countries, like Sweden, Poland, Italy and Latvia, have undertaken some structural reforms by changing the formula used to calculate pension benefits from a DB to a DC scheme. Since the contributions under a DC scheme is linked with benefits straightforward and clearly, a transition to DC scheme could shift the risk from governments to individuals. Furthermore, some countries (Sweden, Germany and Japan) have set up an ABM to adjust the pension parameters based on some indicators that reflect the financial health of the pension system. OECD and European Commissions (OECD, 2015; European Commission, 2012) also provide some future recommendations in order to help member and partner countries to set up a sustainable pension system which at the same time could deliver adequate incomes for retirees. They suggest to restrict early retire-

ment and encourage later retirement, in order to lengthen the contribution periods and shorten the benefit claiming periods. Apart from that, they also recommend to enhance the supplementary pension tiers, such as occupational pensions and private pensions, in order to secure safe and decent incomes after retirement. The recommendations also address the importance to rebuild the trust among the participants in the pension system and link the parametric reforms with ABM.

The following chapter will focus on the pension system in China. Details on the entire pension system in China from its establishment until its present status has been stated in this chapter. This is the first time that the evolution of the entire public pension system in China has been reviewed. The information in this chapter covers not only urban areas and compulsory part but also rural areas and voluntary part. The assessment of current challenges and future directions of pension reforms in Chinese pension system are also presented in this chapter.

Chapter 3

Chinese Pension Systems – Past, Present and Future

Chinese public pension system has undergone several reforms after its establishment in 1951, and its evolution goes hand in hand with the economic background. There are a lot of literature analysing the certain part of the pension system in China. However, the review of the entire public pension system is missing. This chapter aims to fill this gap in the previous works of literature. In general, Chinese public pension system has undergone three stages: 1) preliminary urban and enterprise-based system in the background of central-planned economy from 1951 to 1986; 2) developed system with funded individual account to increase the pension portability and labour mobility in the market competition between state-owned enterprises (SOEs) and private enterprise from 1986 to 1997; 3) gradually standardized pension system starting with the

announcement of State Council Document No. 26 in 1997 till now. Assessment of the current challenges and future directions of pension reforms in Chinese pension system is also provided.

3.1 Introduction

The current public pension system in China has undergone several reforms after its first establishment in 1951. The People's Republic of China, as one of the few pioneer countries who following the productive ownership as socialism, has conducted many reforms in its pension system. The evolution of pensions goes hand in hand with its economic background. The pension system in China has developed from the preliminary stage at which pensions existed only in the state and urban collective sectors within each enterprise to the current comprehensive system which covers urban workers by mandatory participation and other residents both in rural and urban areas by voluntary participation. There are a lot of literature focusing on the analysis for the certain part of the pension system in China. However, the review of the entire pension system is lack. With this in mind, this chapter presents the first review of the entire public pension system in China for its whole history from the establishment to current status together with the economic background in different periods. After that, the assessment of the current challenges in the Chinese pension system is provided. Finally, the future directions of the pension reforms in China are discussed.

Previous studies usually focus on the pension system for employees in urban areas. Since this part is the basis for the Chinese public pension system and has the longest history. Holzmann et al. (2000) and Trinh et al. (2006) stated that Chinese pension system was an urban and enterprise-based scheme until the 1980s, and it was closely linked with the central-planned economy and featured with life-long employment at that time. Zhao and Xu (2002) briefly reviewed the urban pension system from the 1980s to 2001, and addressed that lack of pension portability affects the competition between state-owned enterprises (SOEs) and private enterprise. They found that the funded individual accounts which were established in 1995 with the objective to increase the labour mobility, was not a successful reform due to its bad implementation. Some authors (Dunaway and Arora, 2007; Piggott and Lu, 2007; Oksanen, 2010) claimed that State Council Document No. 26 set the milestone for current pension system by regulating the retirement ages and the requirements for benefits in the pension system. However, West (1999) and Peng (2011) argued that the mixed management of national account and individual account led to increasing empty amount in the funded part. At the same time, Salditt et al. (2007) assessed the pension system from 1997 to 2006, and noted that the coverage of the pension system is very limited under 1997 regulation, as it only covered the urban employees. Dorfman et al. (2013) suggested that China should set up an NDC scheme to cover all the workers both in urban and rural areas.

According to Peng (2011), standardized pension system in rural areas did not exist before 2009. Previously, the management of pensions in rural areas was very frag-

mented and decentralized, and the system in each district was different from others. Dorfman et al. (2013) stated that the new rural pension plan in 2009 set up a national framework for pensions in rural areas at country's level. It indicated that China had made the first step to broader the pension benefit to rural areas. Since then, every rural resident had the access to join the pension system by voluntary participation. Following that, State Council Document No. 18 (State Council, 2011a) has announced central government's decision to set up the pension system for all the urban residents who are not employed. Recently, the two voluntary participated pension systems for urban and rural residents have been merged into one system in 2015. The current public pension system is able to provide free access to all the residents in China.

After the review of the public pension system in China, this chapter discusses the current challenges and the future directions of reforms in Chinese pension system. The severe ageing problem and rapid change of demographic structure in China have led to serious concerns in the PAYG pension system. At the same time, the fast urbanization process and rapid expansion in higher education both put pressures to the future pension system. Furthermore, the recent problems such as 'empty accounts' require the government to rebuild the trust among participants in the pension system urgently. Discussions of future reforms provided in this chapter take into account not only the financial sustainability but also the pension adequacy in China.

The later contents in this chapter are organized as follows. Section 3.2 describes the

evolution of the entire Chinese public pension system[7] according to three different time periods. A brief description of the economic background in China during this time is provided as well. After that, Section 3.3 analyse the current challenges in Chinese pension system. Then, the future directions of pension reforms in China are discussed in Section 3.4. Finally, Section 3.5 concludes the chapter.

3.2 Evolution of the Pension System in China

In general, Chinese public pension system has undergone three main stages. The first stage is the establishment of the preliminary pension system after the foundation of the People's Republic of China, and it is from 1951 to 1986. The second stage is from 1986 to 1997 when the preliminary system has been reformed and developed. The last stage is from 1997 till now, the current structure of the pension system in China has been formed and gradually standardized during this period. A brief description of the economic background in China where the evolution of the pension systems is situated in is provided as follows.

Economic Background in China

This section provides a brief description of the background of the Chinese economy, in which the evolution of the pension systems is situated in. The economy after the foundation of The People's Republic of China can be divided into two periods, which

[7]Pension system in China is operated independently with other parts in the social security system. The structure of Chinese social security system is presented in Appendix C.

is separated by the program of economic reform termed 'Socialism with Chinese characteristics' in December 1978 led by the reformist Deng Xiaoping.

After the foundation of the People's Republic of China, the Communist Party installed a planned economy in China, much like the socialist state Soviet Union (Wu, 2008). Under this plan, the state directed and controlled a large share of the country's economic output, by setting production goals, controlled prices, and allocated resources throughout most of the economy (Feltenstein and Farhadian, 1987). By 1978, the country's industrial production was produced by centrally controlled state-owned enterprises (SOEs) according to centrally planned output targets. There were almost no private enterprises or foreign-invested firms in China (McMillan and Naughton, 1992). It was estimated that China's real GDP grew at an average annual rate of about 5.3 percent from 1960 to 1978 (OECD, 2010a). Because the central planning economic systems and government economic policies put little emphasis on profitability or competition, the country's economy was relatively stagnant and inefficient. As a result, the Chinese living standards were substantially lower than those of many other developing countries (Brandt and Rawski, 2008). Thus, the Chinese government decided to take steps to improve economic growth and raise living standards in the late 1970s.

Economic reforms introducing market-based principles began in 1978 (Garnaut and Song, 2004). This period started with the announcement in the 'Third Plenary Session of Eleventh Central Committee' in 1978 when the reformist Deng Xiaoping introduced the economic plan of 'Socialism with Chinese Characteristics' (Liu, 2009; Wu, 2008). This plan in the late 1970s and early 1980s involved the decollectivization

of agriculture, the opening up of the country to foreign investment, and permission for entrepreneurs to start businesses. The second stage of reform, in the late 1980s and 1990s, involved the privatization and contracting out of much state-owned industry and the lifting of price controls, protectionist policies. The private sector grew remarkably, accounting for as much as 70 percent of China's gross domestic product by 2005 (Wu, 2008). As a part of the decentralization of economic policymaking, provincial and local governments took economic control of various enterprises, allowing them to operate and compete on free market principles. Between the start of an economic reform program in 1978 and 2000, the GDP growth was 9.8 percent a year (OECD, 2010a). In 1999 China became the second largest economy in the world, after the United States.

The following contents provide a review for the evolution of Chinese pension systems in detail.

3.2.1 Establishment of the Preliminary System (1951–1986)

Soon after the foundation of the People's Republic of China in 1949, in order to meet the goal of restoring the national economy and stabilize the national order, the first pension system was introduced in 1951 and regulated under the National Labour Insurance Regulation. It existed only in the state and urban collective sectors[8] and was a pure PAYG system within each enterprise (Holzmann et al., 2000; Trinh et al., 2006).

[8]Collective sectors are enterprises whose ownership belongs to the socialist working population. The enterprise operated as the collective sectors is managed by all the workers in it, and all the workers are responsible for the profit and loss in their enterprise.

At that time, the pension benefit varied from 50% to 70% of the employees' salaries, depending on the number of employed years. The contributions were entirely from the employers, and the contribution rate was 3% of the total salary bills (Cai and Cheng, 2014).

The pension system in China in its preliminary stage was gradually established in the context of the planned economic system (Holzmann et al., 2000). It was the necessary step for the development of the economics at that time. In general, the pension system in this period had the following characteristics:

1. The state and enterprise were in charge of the operation for the pension system together, and enterprise had the primary responsibility. Under this pension system, the state and the enterprise both shared the financial burden to pay the pension benefits. After 1967, the enterprise took the main responsibility to finance the system. The welfare of the participants in the pension system during this period was closely linked with the productive ability in each enterprise.

2. Since the management of the pension system was within each enterprise, the welfare of the pensioners was dependent on the profits earned by each enterprise. It thus led to the significant differences in the benefits among pensioners in different enterprises. Furthermore, it was very hard to set up the same standard for the participants in different enterprises. As a result, it caused the most serious problem, which was lack of labour mobility in the market, i.e. workers were restricted to stay and work for the same employer under this system, otherwise

they would lose their all pension benefits in the future.

3. The financing plan for the pension system during this period was purely PAYG. There was no funded plan under this system. In addition, because the amount of income from contributions was very small at that time, it was very hard for the pension system to reserve any fund during this period.

4. The coverage of the pension was very narrow in this period. Only the pension system for urban workers in collective sectors existed during this time. There was no pension plan for the rural population at that time.

3.2.2 Development of the New System (1986–1997)

Zhao and Xu (2002) described that pension reforms in China went hand in hand with economic reforms. Since the beginning of Chinese economic reforms in the early 1980s, the Chinese urban pension system has undergone a series of reforms.

The 1980s economic reforms encouraged competition in the market between private enterprises and SOEs. Labour mobility was the prerequisite condition for this market competition. However, the previous pension system restricted labour mobility in the market, because changing employment meant a change in pension pools and loss of all the previously accumulated pension benefits from the previous employer (Oksanen, 2010; Zhao and Xu, 2002). The pension system, thus, became a major stumbling

block on the road to economic reforms. The main characteristics of pension reforms during this period is that new pension system replaced the old one which only exists in each enterprise, the local governments (cities or counties) took the management of the pension system. The funded individual accounts were established. The new system consists of two parts. The first part is the national account, and the contribution to which is from employers. The second part is the individual account, and the contribution to which is mainly from employees. The following contents present the details of the evolution for the pension system during this period.

The central government's '7th five-year plan' in 1986 stipulated that both the employees and the employers need to contribute to the pension system in order to set up the social security covering the whole society. From that time, the financial burden in the pension system has been shared among central government, enterprise and individuals contributions together. It implies the beginning of the new pension system in China.

Funded individual accounts were established in 1995 (State Council, 1995) in order to increase the portability of pensions for redundant workers who left SOEs during the economic reforms in the mid-1980s and to increase the labour mobility as well. The contribution to individual accounts was mainly from employees. The accumulation and the interests generated in this account would be paid as the pension benefit to the employees when they retired. However, the system did not work in the way it was intended. Because of large-scale SOE restructuring, many laid-off workers were given immediate pensions at quite young ages (even at 40). This led to deficits in the social

pools of PAYG type (Zhao and Xu, 2002). As a result, local governments used the funds in individual accounts to pay for the pensions of current retirees in the PAYG part, which largely emptied the individual accounts (West, 1999; Peng, 2011). The 'empty accounts' problem has emerged since then.

Because the national pension system at this stage was not unified and the management was highly decentralized. A lot of problems emerged:

1. Since the individual account was managed by the local government, usually on the levels of cities or counties, it thus in practice made the portability of the individual account to be very difficult. Furthermore, it affected the labour mobility in the market.

2. The levels of pension benefit between various districts were very different. The replacement rates in some districts were as high as 105-110%, which led to the huge financial burden to the government. In overall, the average benefit level around the country was relatively high. The average replacement rate was around 86% in China, which was higher than the developed countries by 20-30% at that time (Oksanen, 2010).

3. Since the management of the pension fund belonged to local governments, the ability to disperse the risk was very low. It was very hard for local government to ensure the welfare of the retirees depending on the small social pool of cities or counties.

4. The coverage of the pension system was very narrow. The pension systems in some places only covered the workers in SOEs.

3.2.3 Standardization of the System (1997–present)

In order to solve the problems stated above, the central government has published the State Council Document No. 26 to set up the standards for the pension system in the country. State Council Document No. 26 (State Council, 1997) set the milestone of the current Chinese pension system in 1997 (Dunaway and Arora, 2007; Piggott and Lu, 2007; Oksanen, 2010). It was stipulated that the normal retirement age in China for men is 60 and that for women is 50. The document regulated that the mandatory pension system in China consists of two parts (Salditt et al., 2008). The first part follows a PAYG DB scheme: Employers contribute 20% of the employees' salaries into the social pool managed by local governments, and employees have to contribute for at least 15 years to receive the pension. The second part follows a funded DC scheme: Employers together with the employees contribute 11% of the employees' salaries into individual accounts; the proportion of employees' contribution varies from 4% to 8%, and the remaining contribution is from the employers (Cai and Cheng, 2014). After the 1997 pension reform, pension pools spread to provinces, and all urban workers were expected to participate regardless of ownership (Zhao and Xu, 2002). Although the fund in the individual account was originally designed to be exclusive from the national account, because there had been no regulation regarding the separate management for the two accounts, the 'empty accounts' problem became more and more

severe (West, 1999; Peng, 2011). Thus, to solve this problem, the central government published 'Notice on the Pilot Scheme for Urban Social Security System' in 2000 to regulate the separation between national account and individual account. The central government also announced the decision to gradually fulfil the funded individual account since that time (Salditt et al., 2007).

In 2005, State Council Document No. 38 (State Council, 2005) changed the contribution rate of individual accounts to 8%, and contributions to this part were stipulated to be solely from employees.

Thus, the current Chinese compulsory pension system for urban workers, named urban enterprise pension system (UEPS), has been formed. It consists of two parts. The first part is a PAYG DB type national account with a contribution rate of 20% paid by the employer. The second part is a fully funded DC type individual account to which individuals contribute 8% of their salaries. The fund associated with each account operates separately.

From 2003, some local governments have tried to set up a social security system for the rural old-age population. However, the pension system for the rural population at that time was on a very preliminary stage (Peng, 2011). First, there was no standardized system in the rural areas, the system in each district was different from others. Second, because the level of subsidies from local government as well as the income from the rural population was very low, the benefit for the pensioners was very low.

Third, it was very hard for the system to disperse risk in the whole society, because of the decentralization of the management. Fourth, there was no standard rule for the management of the pension fund, thus almost no interest had been generated in the fund.

The standardized pension system in rural areas has been set up by the central government in 2009 (State Council, 2009). The new pension system is financed by the combination of individual contributions, local government subsidies and central government subsidies, other than the individual's saving alone in previous time (Dorfman et al., 2013). The pension benefit is from two accounts, the national account and individual account. Participants are free to choose from five levels from 100RMB to 500RMB (per year) to contribute into their individual accounts. The local government has to contribute at least 30RMB annually to each individual's account as well. The participants are entitled to the pension benefit, if they reach the age of 60 and have contributed at least 15 years into the system. The pension from the national account is equal to 55RMB each year and is solely from central government's subsidy. The pension from the individual account is dependent on the amount of accumulation and its returns. All the rural residents who are above age 16 and has not participated in the UEPS are voluntary to join the rural citizens pension system (RCPS).

In 2011, the central government has announced the State Council Document No.18 (State Council, 2011b) to set up the pension system for all the urban citizens who are not in employment. The urban citizens pension system (UCPS) has been established,

and all the urban citizens who are above age 16 and has not participated in the UEPS is voluntary to join this system. The structure of this pension scheme is similar to rural citizens. Contributions under this system are still combined with individual contributions, local government subsidies and central government subsidies. The pension benefit is also from two accounts, the national account and individual account. However, the citizens in urban areas could choose higher contribution levels than those in rural areas. Participants are free to choose from ten levels from 100RMB to 1000RMB (per year) to contribute into their individual accounts. Then, the same as rural citizens, The local government's subsidy is equal to at least 30RMB each year. The participants can start to get pension benefit when they reach the age of 60 and have contributed at least 15 years into the system. The pension from the national account is financed by central government's subsidy and is equal to 55RMB each year. The pension from the individual account is dependent on its accumulations and returns.

The summarised information for various public pension schemes in China is presented in Tabel 3.1.

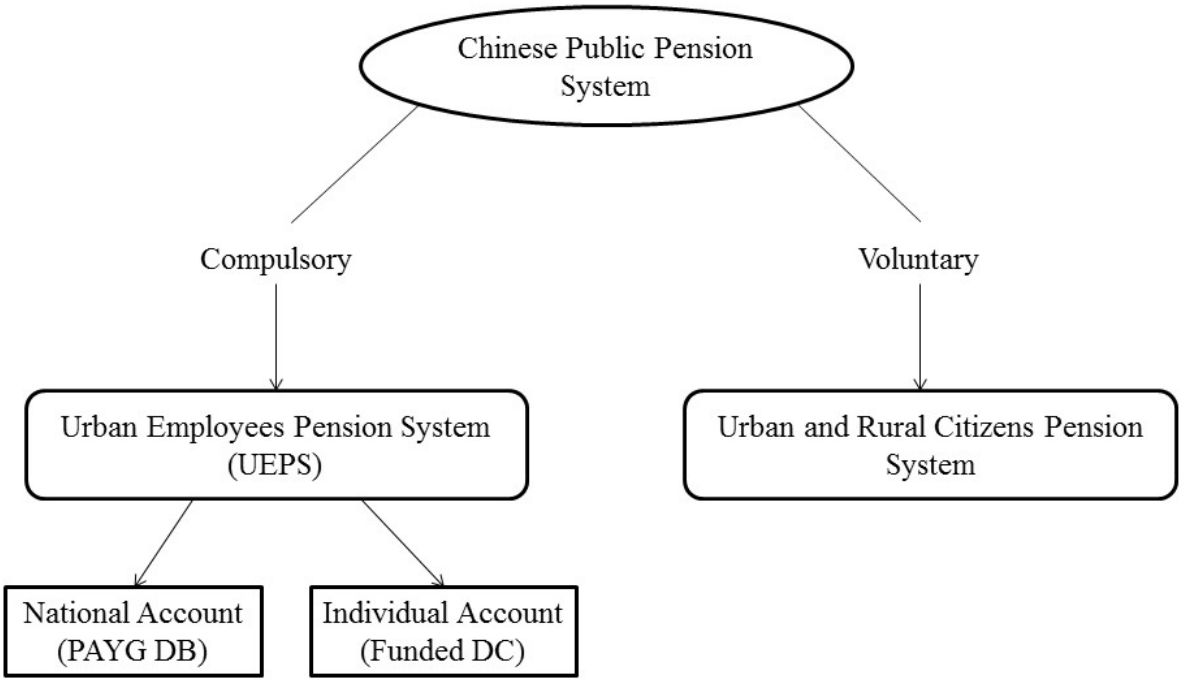
According to the State Council Document No.8 (State Council, 2014), the voluntary pension systems for urban and rural citizens have been unified together since 2015. In addition, the central government's subsidy for the national account has been raised to 70RMB each year since then. The participants are able to choose from twelve levels from 100RMB to 2000RMB (per year) to contribute into their individual accounts. The diagram showing the structure of the Chinese public pension system after 2015 based on its participation types is presented in Figure 3.1.

Table 3.1: Basic information for the public pension system in China

	Urban Enterprise Pension System (UEPS)		Urban Citizens Pension System (UCPS)	Rural Citizens Pension System (RCPS)
Date of establishment	1951 current scheme starts from 1997		2011	2009
Participants	All urban workers		Urban unemployed citizens aged above 16	Rural citizens aged above 16
Contribution	National account: 20% of employees salaries. The contribution is from employers.	Individual account: 8% of employees salaries. The contribution is from employees.	Individuals contributions on various levels + local government's subsidy. Both go into the individual account.	The same as UCPS. But the individual's contribution level is different.
Pension benefit	National account: The amount depends on the average salary and the number of contribution years.	Individual account: The amount depends on the accumulations and the interests in the account.	National account solely financed by central government + Individual Account	The same as UCPS.
Participation type	Compulsory	Compulsory	Voluntary	Voluntary

Own source based on State Council's documents.

Figure 3.1: Structure of Chinese public pension system based on participation type, 2015–present.



Own source

This thesis focus on the analysis of PAYG pension system in the compulsory part of urban workers, i.e. the national account in UEPS. It is not only because this system accounts for the largest part of the compulsory pension system, but also because the original problem of the whole compulsory pension system exists in this part. Detailed information on this PAYG pension scheme is stated below.

PAYG National Account

Contributions. The policy on contributions to this compulsory PAYG scheme has not been changed since 1997. As mentioned before, the contribution is solely from employers, and the contribution rate is equal to 20% of the total salary bills. The contribution goes into the national account, the fund of which is independent of the individual account.

Requirement to collect benefit. The statutory retirement age is 60 for male workers, 55 for female managers, and 50 for other female workers. Many workers, however, are able to collect benefits before the statutory retirement age according to special provisions of the system. Retirement age is reduced for those working in hazardous occupations or who are seriously ill or disabled because of work. For those who have worked in hazardous occupation for the certain number of years and contributed to social security program for at least 15 years, social security receipt age for males and females are 55 and 45. For those being seriously ill or disabled, males can apply for social security benefits at age 50 and females can do this at age 45, on the condition that they have contributed for at least 15 years. Summarised information on the requirements to collect pension benefits in various conditions is presented in Table 3.2.

Benefit formulae. The formula to calculate the initial retirement pension of the Chinese PAYG DB national account, P_t, is expressed as follows:

$$P_t = \frac{1 + WI}{2} \cdot Y_{t-1} \cdot A \cdot 1\%, \tag{3.1}$$

Table 3.2: Requirements to collect pension benefits.

	Retirement age		Contribution years
	Male	Female	Both sexes
Normal retirement	60	55 for manager 50 for other women	at least 15 years
Hazardous occupations	55	45	at least 15 years (special conditions for high altitude and heavy physical occupation–10 years; miner and high temperature occupation–9 years; other health-damaged occupation–8 years.)
Disabled worker	$\geq$50	$\geq$45	at least 15 years
	$<$50	$<$45	at least 15 years (people who has contributed more than 5 years but less than 15 years can top up to 15 years)

Own source based on State Council's documents.

where A is the number of contribution years, Y_{t-1} is the average salary for all contributors in the system at time $t-1$, and WI is the wage index for each individual. WI is an indicator used to measure the relative weight of each individual contribution base with respect to the average contribution base of the total working population. The formula to calculate WI is as follows:

$$WI = \sum_{k=1}^{A} \frac{y_{t-k}}{Y_{t-k} \cdot A}, \tag{3.2}$$

where y_{t-k} is the salary at time $t-k$ for individuals who retire at time t.

3.3 Current Challenges in Chinese Pension System

The problems of longevity and lower fertility have emerged at the global level. However, the severity in China outpaced the world average level.

According to United Nations (2015), the life expectancy at birth in China was 43.39 in the 1950s, however, it has been increasing rapidly to 75.43 in the 2010s. While the world average level has only increased from 46.81 to 70.47 during the same period. Furthermore, the life expectancy at birth in China has exceeded world average level since 1965 and kept increasing recently, as shown in Figure 3.2. Increase of the longevity is a good thing, as people are living longer than before. Because of the rapid economic growth in China, both the living standards and the medical treatment access has been improved rapidly, which help people to get longer lives (Dorfman et al.,

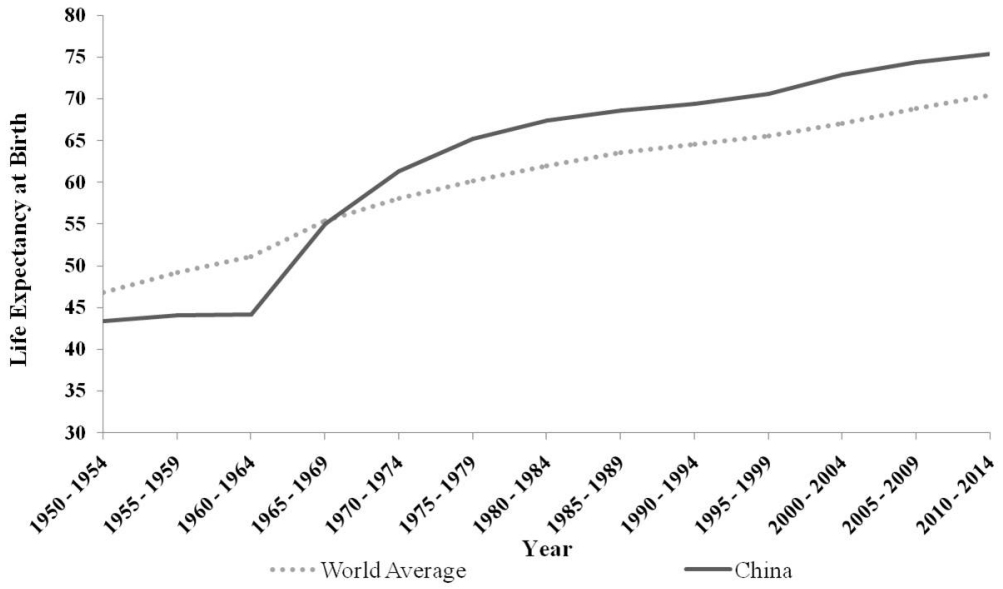
2013). However, the longevity will increase the pension payment periods which in turn affect the financial sustainability of the pension system.

At the same time, the total fertility rates in China dropped from 6.11 (children per woman) to 1.55 during the same period. While the world average level only decreased from 4.96 to 2.51 during this time. The current fertility rate in China is below 2, which means the total number of population is diminishing because a pair of the parent cannot reproduce at least two babies. The rapid decreasing of total fertility rates was mainly due to the one-child policy which had been introduced in 1979. Figure 3.3 depicts the evolution of total fertility rates in China and in world average level, together with the relevant events indicated. The one-child once introduced has dropped the fertility rate in China down above the world average level. And this policy kept decreasing the total fertility rate in China thereafter. Rapid decreases in the fertility rates will lead to the reduction of the working-age population, hence decrease the income from contributions in the pension system.

Increasing longevity and decreasing fertility have led to an increasing old-age dependency ratio and a rapidly ageing society in China. As shown in Figure 3.4, the old-age dependency ratio (aged 65+/aged 15-64) in China was increasing more rapidly from 7.3% in 1950 to 13% in 2015 than the world average level from 8.4% to 12.6% during the same period. Recently, this ratio in China has become higher than the world average in 2015.

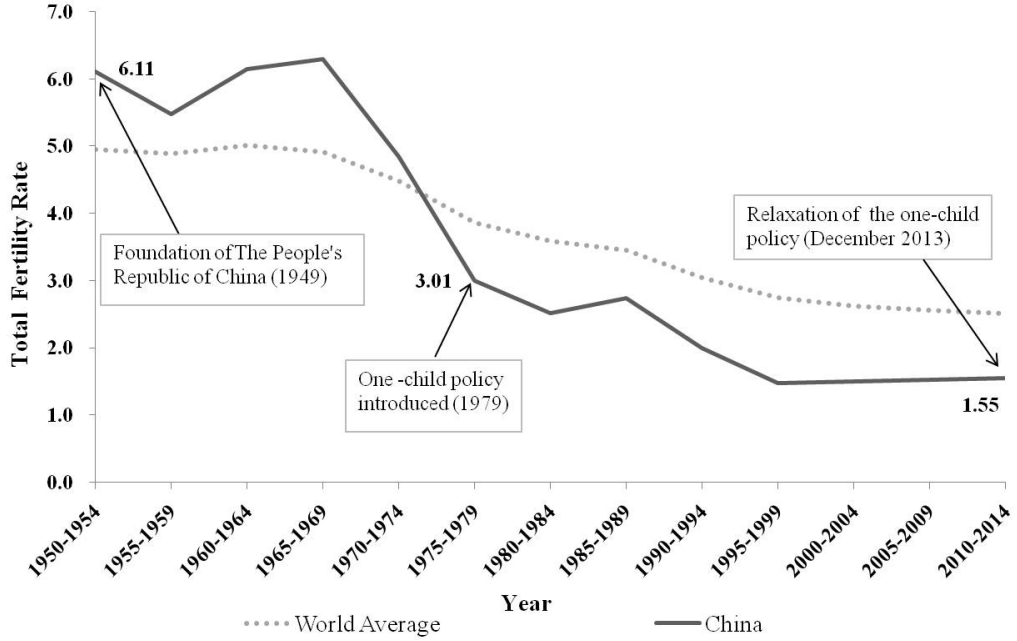
Furthermore, based on the population data provided by United Nations (2015), the elderly population (aged 60+) in China is equal to 201 million in 2015, which is now more than the entire population of Japan and the United Kingdom equal to 127 million and 65 million respectively. With higher life expectancy and lower fertility, the population in China is severely ageing both in absolute terms as measured by the total number of elderly population and in relative terms as measured by the proportion of elderly compared to the working-age population (old-age dependency ratio).

Figure 3.2: Life expectancy at birth for China and World



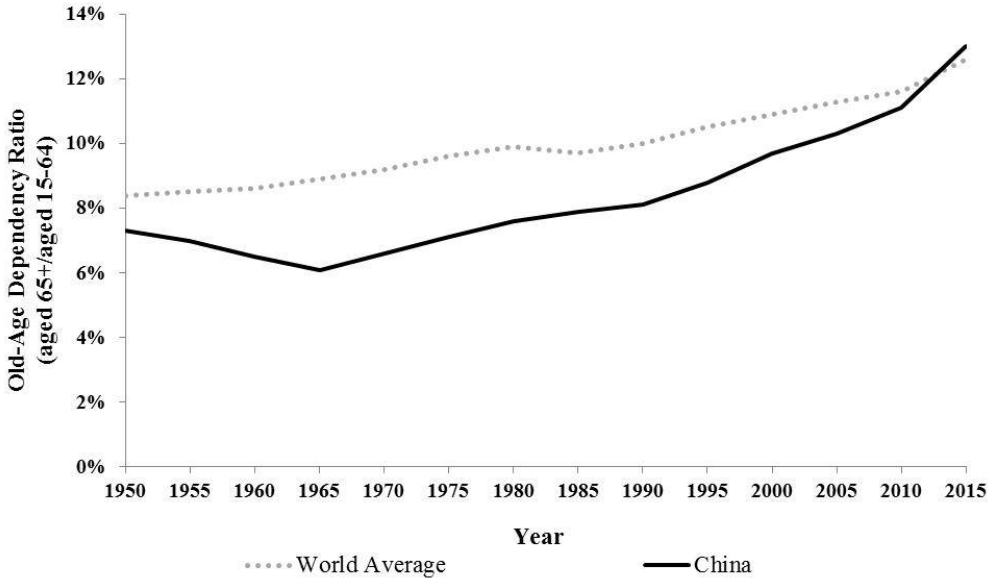
Own source based on United Nations (2015)

Figure 3.3: Total fertility rates for China and World



Own source based on United Nations (2015)

Figure 3.4: Old-age dependency ratio (aged 65+/aged 15-64) for China and World



Own source based on United Nations (2015)

The challenges in Chinese pension system has not stopped so far. The increased living standards and spread access to healthcare will continue to push life expectancy to a

new higher level in China.

At the same time, China's college education annual enrollment has been tripled, from 2.2 million to 6.6 million in the last decade (Cai and Cheng, 2014). As a result of the expansion in higher education, the size of the young labour force will decline, and Howden and Zhou (2014) found that the working population in China had started to decline in 2012. On the condition of no pension reform on the retirement age, the later people enter the labour market will lead to shorter contribution period. Thus, it will reduce the total amount of income from contributions. Finally, the financial imbalance between the incomes and expenditures will happen, and cause serious problems to a PAYG pension system.

The pending problem of 'empty accounts' makes participants lose confidence in the transparency of the current pension system. According to Zheng (2016), the accrued amount in individual accounts is equal to 4097 billion RMB until the end of 2014, while the accumulated fund in UEPS is only 3180 billion RMB. Since the participants cannot perceive their future benefit in the current pension system, they will try to leave the labour market or create some forms of employment which can avoid participation in the pension system. As the origin of the 'empty accounts' comes from the financial deficits in national account, the only way to solve this problem and regain the credibility among the participants is to construct a sustainable pension system in the PAYG system.

Furthermore, the recent trend of urbanization has transited a large amount of working-age population from rural to urban areas. The huge inflow of the young population might facilitate the current economic development in urban areas, however, it will lead to the heavy financial burden to the urban pension system in the future.

In overall, analysis of the pension system in China and implementation of the pension reforms to restore the sustainability of Chinese pension system are demographically urgent, economically necessary and socially and politically essential.

3.4 Future Directions of Pension Reforms in China

The future directions of the pension reforms in China should be based on two principle objectives – adequacy and sustainability. With these objectives in mind, the following contents discuss the future directions of pension reforms in China.

Future Reforms regarding Pension Adequacy

As mentioned before, in order to achieve the pension adequacy, the first step is to ensure every individual could get access to the pensions. However, currently in China, the UEPS has not covered all the urban employed workers yet. In order to avoid paying higher contributions into the pension system (As mentioned before, the employers need to pay 20% of employees' salary bills into the system), some private enterprises tends to pay a higher salary for their employees as a negotiation for their compromises

to be not enrolled in the pensions (Pozen, 2013; Dorfman et al., 2013). On the other side, it is often very difficult to record the pension credits for people who take short-term careers or part-time jobs. And, this is not only the problem in China but also the problem around the world. According to OECD (2015), only about three out of ten older people have received some support from public pensions on average across OECD countries. The Chinese government is trying to cover all the urban workers into the UEPS, and the growth number of new participants keeps increasing recently at an average rate of 7.31% from 2007 to 2015 (Ministry of Human Resources and Social Security of the People's Republic of China, 2015). Future reforms should also focus on broadening the coverage to supply pensions to every urban worker. Furthermore, Dorfman et al. (2013) suggested that the pension system in the future should cover all the workers regardless of the region.

The current regulation for people to collect pension entitlements requires at least 15 years contribution into the pension system. The requirement for the contribution periods could be shortened in the future in order to spread pensions to more people. For example, Japan has planned to decrease its required contribution years to get the national pension from 25 to 10 years from April 2017 (Ministry of Health, Labour and Welfare, 2015). On the other side, currently only disabled worker whose age is below 50 for men and 45 for women is eligible to pay additional voluntary payment to make up their contribution gaps for pension benefits (see Table 3.2). The coverage of this additional payment could be spread to every worker in the future, in order to help more people get the adequate pension after their retirement.

In 2015, the Chinese central government has decided to merge UCPS and RCPS into one system called urban and rural citizens pension system (detailed information is presented in Section 3.2). It implies that the government is trying to reduce the management and administration costs by unifying the pension systems. It also helps to reduce costs to set the standard rules in the unified pension system. The future direction of reforms in this aspect could focus on enhancing the voluntary complementary pension schemes. On the other side, the Chinese government has decided to set up an electronic pension data management system called 'Golden Insurance Project' in 2010 at the national level. However, the implementation is still in process as it requires a lot of human and financial resources. In the future, the government could also provide pension education and advice to individuals through this project.

The Chinese government also tried to diversify its investment portfolios on pension fund. It has been approved that up to 30% of the pension fund could be invested in the domestic stock market since August 17th, 2015. While previously, the pension fund was only allowed to be invested in the bank deposits and treasury bonds with a very low yield. Future directions could develop the portfolio to include more kinds of investments, such as foreign currencies and foreign stocks.

Future Reforms regarding Financial Sustainability

The paramount objective of a pension system is to achieve the financial sustainability. It is impossible for a bankrupted system to provide adequate pensions to its partic-

ipants. A system which is not sustainable in the long term cannot even fulfill the promises to pay benefits, not ever mentioned to obtain the pension adequacy. Thus, to ensure the financial sustainability is the most important thing in a pension system.

As we have mentioned before, the most common measure to improve the financial sustainability is to increase the retirement age. Thus, the current popular recommendation on the pension reform in China is to increase the statutory retirement age for both genders to 65 years old. Cai and Zhang (2015) and Zheng (2011) mentioned that the current statutory retirement age in China has not been changed since the establishment of the pension system. The current statutory retirement age is 60 for male, 55 for female managers and 50 for female workers, which is much lower than the majority of the countries. The retirement age in most of the countries around the world is equal to 65 years old (see Table 2.2). The retirement age in these countries has been continuing to be adjusted with the increase of the life expectancies. Thus, the reform in China is urgent. This recommendation has been formally proposed to the State Council in the 2015 annual sessions of NPC & CPPCC (The National People's Congress of the People's Republic of China & The National Committee of The Chinese People's Political Consultative Conference), and it is currently under the consideration of the State Council.

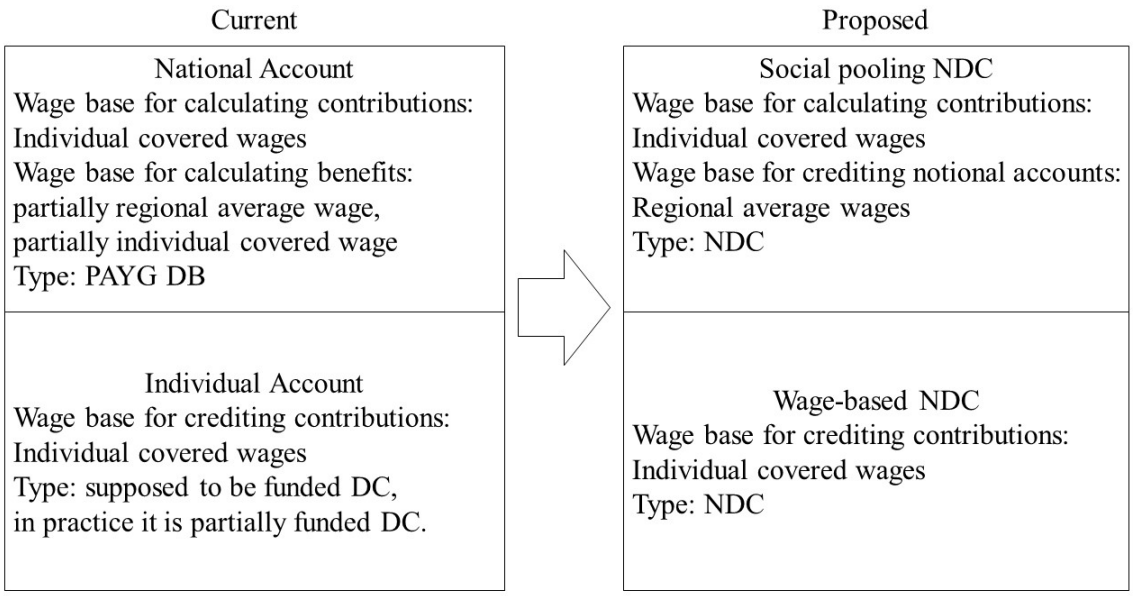
The other measures regarding parametric reforms such as decreasing indexation on pensions or increasing contribution rates could also be taken during the future pension reforms. As mentioned before, China has not had any fixed indexation policy on

pensions now. At the same time, the current contribution rate for the PAYG national account in China has not been changed since 1997. However, in the current context of severe ageing and rapid change in demographic structures, providing the review of the pension system and taking corresponding pension reforms on a regular basis is necessary for China. By reviewing the current trend around the world (Detailed information on the pension reforms around the world is presented in Section 2.3.), the advancement of future parametric reforms could be obtained through directly linking the parameters with financial sustainability. Furthermore, ABM should be introduced in China in order to secure the long-term sustainability of the pension system in a more effect and efficient way.

Another suggestion on the future pension reforms focuses on the change of current pension structures. Considering that the 'empty accounts' in the individual accounts is difficult to be refilled, and the DC schemes could better link contributions with benefits. Oksanen (2010), Dorfman et al. (2013) and Zheng (2014) recommend China to change its current UEPS (PAYG DB + Funded DC) to NDC scheme. The structure of the new NDC scheme is presented in Figure A.1. The current national account which following the PAYG DB scheme is proposed to be changed in an NDC account. A further modification is recommended on the calculation of pension benefits. In the previous DB account, both regional average wage and individuals wage are taken into account, while the new proposal in social pooling account only considers regional average wage. As mentioned before, the current individual account is originally designed and supposed to be a funded DC scheme, however, the problem of 'empty accounts'

make it be a partially funded DC scheme in practice. Currently, the government is making efforts to fulfill the individual accounts by the government revenues. The new scheme in the proposal replaces the current individual accounts by a wage-based NDC scheme.

Figure 3.5: Current and proposed structural reforms in China



Own source based on Dorfman et al. (2013)

Other reforms, which have been raised by OECD for its member and partner countries in order to achieve the sustainable and adequate pension systems (see Section 2.3), should also be considered during the future pension reforms in China. The following analysis in this thesis is also helpful to the implementation of these recommendations. For example, Chapter 4 provides the actuarial reports for the pension system which aims to increase the transparency and rebuild the trust among the participants. After that, Chapter 5 and Chapter 6 set up the ABM for China under different fertility and migration policies, it helps people to better understand how the different policies could

affect the sustainability in the context of ageing. Furthermore, the establishment of the ABM could help the pension system to response the rapid changes of low fertilities and rapid urbanization more efficiently.

3.5 Summary

This chapter first reviews the entire public pension system in China from its establishment to current status by dividing the evolution into three stages. The first stage is from 1951 to 1986, as the preliminary pension system was first established in 1951. It was an urban and enterprise-based system featured with life-long employment of the central-planned economic system. In the 1980s, the economic reforms in China encouraged the competition between SOEs and private enterprises. Thus, the second stage of pension system reform in China from 1986 to 1997 aimed to increase the pension portability and labour mobility in the market. A funded individual account was introduced in 1995 with this purpose. After that, State Council Document No. 26 State Council (1997) set the milestone of the current Chinese pension system in 1997. It implied the beginning of the third stage when the system was gradually reformed with standardization till now. The current public pension system in China consists of two parts, that is the compulsory UEPS covering urban employees and the voluntary Urban and Rural Citizens Pension System covering all the other citizens who have not participated in UEPS.

This chapter also assesses the current challenges in the Chinese pension system. Ageing problems in China present more severe situation than the world average level. Since the situation will lengthen the pension payment periods and reduce the income from contributions at the same time, it thus will affect the financial sustainability of the PAYG pension system. The pressures brought about by the other changes in Chinese society, such as expansion in higher education and rapid process of urbanization, are also addressed in this chapter. Apart from that, rebuilding the trust of participants in the pension system is urgent as well.

Discussions on future directions of pension reforms for China in this chapter take into account not only financial sustainability but also pension adequacy. Reforms to improve the pension adequacy in China includes: increasing the coverage of UEPS; lowering the required contribution years for pensions in order to provide more people with pension entitlements; developing the pension information system and provide free education and advice on pensions; and diversifying the investment portfolios in pension fund to include more choices, such as, foreign currencies and stocks. Future pension reforms directly target at the financial sustainability in China are: increasing statutory retirement age for both genders to 65 years old; setting up an ABM to link the parametric reforms with the financial status of the pension system directly; and transferring the current UEPS system to NDC schemes.

Chapter 4

Sustainability Indicators

This chapter analyses the Chinese contributory PAYG pension system in the urban area over the period 2007-2012 using two actuarial balance methodologies. First, we use the Swedish solvency ratio (SR) to analyse the solvency of the Chinese pension system based on verifiable facts. Second, the United States' actuarial balance indicator (AB), that takes into account the projected demographic and economic scenario is calculated. This is the first estimate of solvency/sustainability levels of the Chinese PAYG pension system. Both methodologies show that the Chinese pension system in its current form is neither sustainable nor solvent. The chapter also provides some advice on the parametric reforms that should be undertaken to restore the financial health of the system.

4.1 Introduction

Pay-as-you-go (PAYG) pension systems require a balance between the benefits paid to pensioners and the contributions made by active workers. The decline in fertility rates and the increase in longevity will contribute to a substantial increase in the old-age dependency ratio, and this will raise serious concerns for the sustainability of PAYG pension systems. This is a worldwide problem, and many European countries have already carried out some parametric reforms[9], such as, an increase of the retirement age or a decrease of the indexation on pensions to reduce the expenditure on pensions.

Countries, such as Sweden, Poland, Italy and Latvia have undertaken some structural reforms by changing the formula to calculate their initial pension from a defined benefit (DB) to a notional defined contribution (NDC) pension scheme (Holzmann et al., 2012; Vidal-Meliá et al., 2010), or even to a fully funded scheme like the Chilean case.

In the meantime, some countries, such as Sweden, Germany and Japan, have decided to set up an automatic balance mechanism (ABM) according to an indicator[10] that reflects the financial health of the system.

In Asia[11], the situation presents a greater challenge. The speed of ageing in Asia is much faster than it is in Europe. According to United Nations (2015), the old-age dependency ratio for Europe is forecast to increase from 24% in the early 2010s to

[9] Pension reforms in European countries can be found in Boeri et al. (2013), OECD (2015) and Whiteford and Whitehouse (2006).

[10] See Vidal-Meliá et al. (2009, 2010) and OECD (2012) for more details on ABM.

[11] Pension reforms in Asian countries can be found in Hujo and Cook (2012).

50% by the 2080s, while in Asia it will increase from 10% to 42% during the same period. Japan, which has one of the most severe ageing problems, has taken several measures, including increasing the retirement age from 60 to 65 and setting up an ABM (called the modified indexation[12]) that is applied to both the revaluation of contribution bases and pensions in payment, taking into account improvements in life expectancy and population decreases. According to Moon (2009), South Korea has decreased the replacement rate for the retirement contingency from 60% to 50% and is currently scheduled to fall further to 40% by 2028. Also, they are considering transferring to an NDC scheme and setting up an ABM (Bonnet et al., 2010). At the same time, Vietnam is considering to transfer from PAYG DB to partially funded defined contribution (DC) (Giang, 2013). Pension systems in countries such as Thailand and India, that are not widely covered in the national scale, have conducted many reforms and recently they both plan to transfer to a funded DC system[13].

In some former British colonies, such as Singapore or Malaysia, the central provident fund (CPF) is a compulsory comprehensive savings plan designed to fund mainly retirement and healthcare. The CPF was not a good solution given early withdrawals. In Singapore, the retirement age has been increased from 55 in 1993 to 62 recently and is proposed to raise to 67 in the future while the contribution rate has increased by 1.5% as stated in Asher and Bali (2015) and Asher and Rajan (2002). Malaysia has increased the contribution rate from an initial 10% to 23% and also set restrictions on early withdraws (Asher and Bali, 2012; Tolos et al., 2014).

[12]See Sakamoto (2005) for more details.

[13]See Brustad (2012) and Holzmann et al. (2000) for details on Thailand and Bali (2014) for details on India.

In China[14], the problem is made worse by the one-child policy which was implemented in the 1980s, and has only recently been relaxed. The policy led to a sharp decline in fertility rates from 6.11 in the 1950s to 1.55 in the 2010s, and as a result, a decrease in the number of contributors financing each pensioner from 13.2 in the 1980s to a projected 1.6 in the 2080s according to United Nations (2015). China has tried to solve the problem by decreasing the replacement rates in urban areas from 77% to 45% in the last decade (OECD, 2010b) and is currently considering to increase the statutory retirement age from 50 of women and 60 of men to 65 for both sexes. At the same time, China has introduced longevity insurance annuities to maintain the living standard of elder people (Chen and Turner, 2014). Finally, as stated by Oksanen (2010), Dorfman et al. (2013) and Zheng (2014), China is also considering to transfer its pension scheme to NDC.

This chapter analyses the long-term sustainability of the Chinese PAYG pension system in urban areas using two actuarial models–The Swedish solvency ratio (SR) based on the verifiable facts and the United States' actuarial balance indicator (AB) which takes into account the projected demographic and economic structures in the next 75 years.

Following this introduction, the remainder of this chapter is structured as follows. Section 4.2 introduces the methodologies to calculate the Swedish solvency ratio and the United States' actuarial balance indicator. Section 4.3 analyses the Chinese pension system following the Swedish methodology. This section also includes a description

[14]Information on pension reforms in China can be found in Dorfman et al. (2013)

of the data and main assumptions, together with a comparison with Swedish pension system and some advice on the parametric reforms. Section 4.4 analyses the Chinese pension system using the United States' methodology. This section also contains a description of the data and main assumptions, together with a comparison with the United States' pension system and a discussion of possible parametric reforms. Section 4.5 provides the summary of this chapter.

4.2 Methodologies

This section describes the methodologies used to calculate the Swedish solvency ratio (SR) and the United States' actuarial balance indicator (AB). These are two different methodologies to analyse the long-term sustainability of the pension system.

The Swedish model is based on the verifiable facts. It analyses the assets and liabilities accrued for the current contributors and pensioners in the pension system. The future changes in the demographic and economic structures do not affect the analysis in this methodology. The Swedish model requires the government to compile an actuarial balance sheet for the pension system on an annual basis. The methodology to calculate the Swedish SR is provided in Section 4.2.1.

On the other hand, the United States' model makes projections on the demographic and economic structures over the next 75 years. It analyses the differences between the present values of the pension expenditures and the contributions. The AB indicates

how much the current contribution rate should increase for the system to be sustainable over the next 75 years. The methodology to calculate the United States' AB is provided in Section 4.2.2.

4.2.1 The Swedish Solvency Ratio (SR)

The actuarial balance sheet has been developed and applied by Sweden on an annual basis since 2001. It is an actuarial balance sheet in the accounting sense of the term and can be defined as the financial statement listing a pension system's obligations towards contributors and pensioners together with the amount of assets that back up those liabilities[15]. The main aim of the actuarial balance sheet is to give a true and fair view of the pension system's solvency, by comparing the assets and liabilities every year. Compiling the actuarial balance sheet gives transparency into the pension system at the same time it increases the confidence of contributors and pensioners.

On an official level, the actuarial balance sheet has not been used outside Sweden, although in the cases of Japan and Spain an actuarial balance sheet has been used by researchers[16].

The structure of the actuarial balance sheet is shown in Table 4.1:

[15]Detailed information can be seen in Boado-Penas et al. (2008), Boado-Penas and Vidal-Meliá (2012) and Swedish Pensions Agency (2013).

[16]See Boado-Penas et al. (2008) for Spain and Takayama (2005) for Japan.

Table 4.1: Main entries on the actuarial balance sheet of a pay-as-you-go pension system

Assets	*Liabilities*
Financial assets	Liability to pensioners
Total assets	**Total liabilities**

The system is solvent[17] (or sustainable) as long as: (Financial assets + Contribution assets) $\geqslant$ (Liability to pensioners + Liability to contributors). This implies that the accumulated deficit must be nil or negative or the solvency ratio (SR), defined as the relation between assets and liabilities of the system, must be equal to or greater than 1. In this particular case, the participants in the system would have reasonable expectations that the promises of payments would be respected, without the sponsor of the system (the state government) having to make non-statutory contributions. However, if (Financial assets + Contribution assets) $<$ (Liability to pensioners + Liability to contributors) or the accumulated deficit is positive, the pension system is insolvent (or unsustainable), and the promises of the participants might be broken without the sponsorship of the government.

In Sweden, if the actuarial balance sheet reveals that the system is insolvent, an automatic balance mechanism (ABM) will be triggered with the aim of reducing the growth of the liabilities[18].

[17] According to Knell et al. (2006), the term sustainability has many definitions, though it almost always refers to the fiscal policies of a government, the public sector or the pension system. On the other hand, the concept of solvency particularly refers to the ability of a pension scheme's assets to meet the scheme's liabilities indicator. Henceforth we use the term sustainability when compiling the United States' actuarial balance methodology and solvency for the Swedish actuarial balance sheet methodology. Solvency is a kind of sustainability.

[18] Detailed information on the Swedish ABM can be found in Swedish Pensions Agency (2013) and Vidal-Meliá et al. (2009).

A description of the main entries on the actuarial balance sheet is provided below. The formulae developed are based on Boado-Penas et al. (2008) but applied to Chinese data.

Liabilities to Pensioners

Liabilities to pensioners are calculated as the present value of current and future pensions for current pensioners. The formula to calculate liabilities to pensioners, V_t^r , is expressed as follows:

$$V_t^r = \sum_{k=0}^{w-x_e-A-1} P_{(x_e+A+k,t)} N_{(x_e+A+k,t)} \ddot{a}_{x_e+A+k}^{\lambda} \tag{4.1}$$

where $w-1$ is the maximum age at which people can survive; x_e is the entry age into the pension system; $P_{(x_e+A+k,t)}$ is the amount of the retirement pension at time t for individuals aged x_e+A+k; $N_{(x_e+A+k,t)}$ is the number of pensioners aged x_e+A+k at time t, and $\ddot{a}_{x_e+A+k}^{\lambda}$ is the present value of a lifetime annuity due of 1 per year payable in advance growing at real rate λ, valued at age $x_e + A + k$, with a technical interest rate equal to δ.

Liabilities to Contributors

Liabilities to contributors are calculated as the difference between the present value of future pensions and future contributions[19]. The formula to calculate liabilities to contributors, V_t^c , is expressed as follows:

$$V_t^c = \overbrace{P_{(x_e+A,t)} N_{(x_e+A,t)} \ddot{a}^{\lambda}_{x_e+A} \sum_{h=1}^{A} \left(\frac{1+g}{1+\delta}\right)^h}^{\text{Future pensions}} - \overbrace{c_t \sum_{k=0}^{A-1} \sum_{h=0}^{k} N_{(x_e+k,t)} y_{(x_e+k,t)} \left(\frac{1+g}{1+\delta}\right)^h}^{\text{Future contributions}} \tag{4.2}$$

where $P_{(x_e+A,t)}$ is the amount of initial pension for current contributors who retires at time t; $N_{(x_e+A,t)}$ is the number of current contributors who reach retirement at the normal age $x_e + A$ at time t; $\ddot{a}_{x_e+A}$ is the present value of a life annuity valued at age $x_e + A$; $N_{(x_e+k,t)}$ is the number of contributors aged $x_e + k$ at time t; $y_{(x_e+k,t)}$ is the average salary for people aged $x_e + k$ at time t; c_t is the contribution rate at t; g is the growth rate of salary and δ is the discount rate.

Contribution Asset

The novel entry on the PAYG actuarial balance sheet is the contribution asset (CA) defined by Settergren (2001, 2003), Settergren and Mikula (2005) and the literature of Swedish Pensions Agency. The formula to calculate the contribution asset at time t,

[19]This method, also called prospective method, is used due to the DB nature of the Chinese PAYG pension system. For more detailed information see Boado-Penas et al. (2008), Vidal-Meliá et al. (2009) and Boado-Penas and Vidal-Meliá (2012).

CA_t , is expressed as:

$$CA_t = TD_t \cdot C_t = (A_t^r - A_t^c) \cdot C_t \tag{4.3}$$

Where TD_t[20] is the turnover duration, which is the time expected to pass from a monetary unit enters the system as a contribution until it leaves in the form of a pension; C_t is total contribution revenue at year t; A_t^r is the average weighted age for the pensioners (weighted by the amount of annual pensions considering the age-benefit profile), and A_t^c is the average weighted age for the contributors (weighted by the amount of real contributions considering the age-earnings profile)[21].

4.2.2 The United States' Actuarial Balance Indicator (AB)

The main methodology used to compile the actuarial balance in non-financial DB systems could be described as an aggregate accounting projection model that compares the spending on pensions with the income from contributions. It basically involves using the forecast demographic scenario to determine the future evolution of the number of contributors and pensioners according to the rules of the pension system. The macroeconomic scenario that determines the amounts of future contributions and pensions is exogenous.

[20] Detailed information can be found in Boado-Penas et al. (2008) and Settergren and Mikula (2005).

[21] Formulae to calculate the average weighted ages for the pensioners and the contributors are provided in Appendix D.

The United States follows this methodology and has compiled an actuarial balance annually since 1941 (The Board of Trustees, Federal Old-Age And Survivors Insurance and Federal Disability Insurance Trust Funds, 2012). The United States' actuarial balance indicator (AB) measures the system's financial sustainability by measuring the difference in present value, discounted at the projected yield, between spending on pensions and income from contributions, taking into account that the level of financial reserves at the end of the time horizon reaches a magnitude of one-year expenditure. This value summarises the system's financial deficit or surplus for the 75-year horizon.

Other countries such as Canada, Finland, Germany and the United Kingdom also follow the main aggregate accounting methodology, but some particularities and the way in which the main results are presented differ from those in the United States actuarial balance[22].

The formula to calculate the United States' AB is shown as follows:

$$AB = \underbrace{\left[\frac{TF_0 + \overbrace{y_0 \cdot \sum_{t=0}^{74} c_t \cdot N_t \cdot \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_h)}}^{Present\ value\ of\ Contributions}}{\underbrace{y_0 \cdot \sum_{t=0}^{74} N_t \cdot \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_h)}}_{Present\ value\ of\ payrolls}}\right]}_{Summarized\ Income\ Rate} - \underbrace{\left[\frac{\overbrace{P_0 \cdot \sum_{t=0}^{74} R_t \cdot \prod_{h=1}^{t} \frac{(1+\lambda_h)}{(1+r_h)}}^{Present\ value\ of\ benefits} + \prod_{h=1}^{74} \frac{(TF_{74})}{(1+r_h)}}{\underbrace{y_0 \cdot \sum_{t=0}^{74} N_t \cdot \prod_{h=1}^{t} \frac{(1+g_h)}{(1+r_h)}}_{Present\ value\ of\ payrolls}}\right]}_{Summarized\ Cost\ Rate} \tag{4.4}$$

where TF_0 denotes the value of assets in the trust fund at the beginning of the period; c_t is contribution rate at t; y_0 denotes the contribution base at the beginning; N_t denotes

[22] See Boado-Penas and Vidal-Meliá (2012).

the number of contributors at year t; g is the annual wage growth rate; r is the projected yield rate on trust fund assets; P_0 denotes the average pension at the beginning; R_t denotes the number of pensioners at year t, and λ is the annual indexation of pensions.

If $AB \geqslant 0$, then the system is sustainable for the next 75 years. If $AB < 0$, the system is unsustainable.

4.3 Analysis of Chinese Pension System based on Swedish Methodology

This section shows the first estimate of the actuarial balance sheet for the Chinese pension system with the aim of producing a solvency ratio (SR) over the period 2007-2012. A comparison with the Swedish pension system is also provided together with some parametric reforms to restore the sustainability of the Chinese pension system.

4.3.1 Data and Assumptions

- The effective retirement age in China is 53[23].

- Data on financial assets is obtained from National Social Security Fund Report

[23]In China, the effective retirement age does not coincide with the statutory normal retirement age which is 60 for men and 50 for women. For detailed information on the effective retirement age, see "Enterprise Retiree Basic Situation Investigation" published by Ministry of Labor and Social Security of the People's Republic of China (2006).

(Ministry of Human Resources and Social Security of the People's Republic of China, 2012b), while contribution revenues are from Human Resources and Social Security Statistics Bulletin (Ministry of Human Resources and Social Security of the People's Republic of China, 2012a).

- The total number of contributors is obtained from Human Resources and Social Security Statistics Bulletin. We assume that the distribution of the number of contributors per age group follows the same age distribution as the number of urban employed workers[24]. Distribution of urban employed workers per age group is from China Population and Employment Statistics Yearbook 2012 (Department of Population and Employment Statistics, National Bureau of Statistics of China, 2013).

- The total number of pensioners is obtained from Human Resources and Social Security Statistics Bulletin. Distribution of pensioners per age group follows the same distribution for urban people aged over 53. Distribution for urban people aged over 53 per age group is from China Population and Employment Statistics Yearbook.

- Data on the average monthly wage[25] for current workers is from National Bureau of Statistics of the People's Republic of China. Wage distribution per age group is from the Ministry of Human Resources and Social Security of the People's

[24] In China, not all the urban employed workers are covered by the pension system, though the Chinese government is trying to cover all the workers in the future. Currently the number of contributors is less than the number of urban employed workers

[25] The terms contribution base, salary and wage are used as synonyms in this thesis.

Republic of China. Salaries are kept constant in real terms per age group.

- The mortality tables are from China Population and Employment Statistics Yearbook[26].

- It is assumed that once individuals enter the labour market, they contribute throughout their working lives with 100% density.

- The discount rate for future pensions and contributions should be consistent with the one for the contribution asset, and this rate is assumed to be 0%. It should be noted that the system's SR depends on the relation between assets and liabilities and not the exact amount of assets and liabilities (Boado-Penas et al., 2008).

- We assume that the number of contribution years is equal to 33 in the normal scenario[27].

4.3.2 SR for China

Table 4.2 shows that the SR for China is always around 0.4 over the period 2007-2012, which means the total liabilities are more than double the total assets. This implies that the Chinese pension system is insolvent. At the same time, the degree of funding of the

[26]The mortality tables for China from China Population and Employment Statistics Yearbook are provided in Appendix E.

[27]This assumption is made following the advice of the experts on the Chinese pension system in 2014. The legal retirement age for men (60) and women (50) are used to calculate the total contribution years. Information on the calculation of the contribution years is provided in Appendix F.

Chinese PAYG pension system remains low, barely reaching 2.05% in 2012, while in Sweden, the degree of funding is 12.05% in 2012 as shown in Table 4.3. The share of liabilities to contributors within total liabilities is 56% in China, which is 9.1% points lower than in the Swedish pension system.

Table 4.2: Balance sheet for the Chinese pension system at 31 December each year

Contribution Years = 33	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Asset (% of GDP)						
Financial asset	2.30	2.60	3.14	3.49	3.75	4.22
Contribution asset	58.84	61.10	67.91	68.90	72.81	76.73
Accumulated deficit	84.28	84.28	93.96	111.00	109.30	113.79
'Loss for the period'	0.00	9.68	17.04	-1.70	4.49	11.14
Total assets	145.42	157.66	182.06	181.70	190.35	205.88
Liabilities (% of GDP)						
Liability to pensioners	64.15	69.76	80.67	83.25	84.54	90.63
Liability to contributors	81.27	87.90	101.39	98.44	105.81	115.25
Total liabilities	145.42	157.66	182.06	181.70	190.35	205.88
Funding, solvency and liquidity indicators						
Ratio of (in)solvency (assets/liabilities)	0.420	0.404	0.390	0.398	0.402	0.393
Degree of funding(%) (financial asset/liabilities)	1.58	1.65	1.73	1.92	1.97	2.05
Liabilities to contributors/ liabilities(%)	55.9	55.8	55.7	54.2	55.6	56.0

Own source

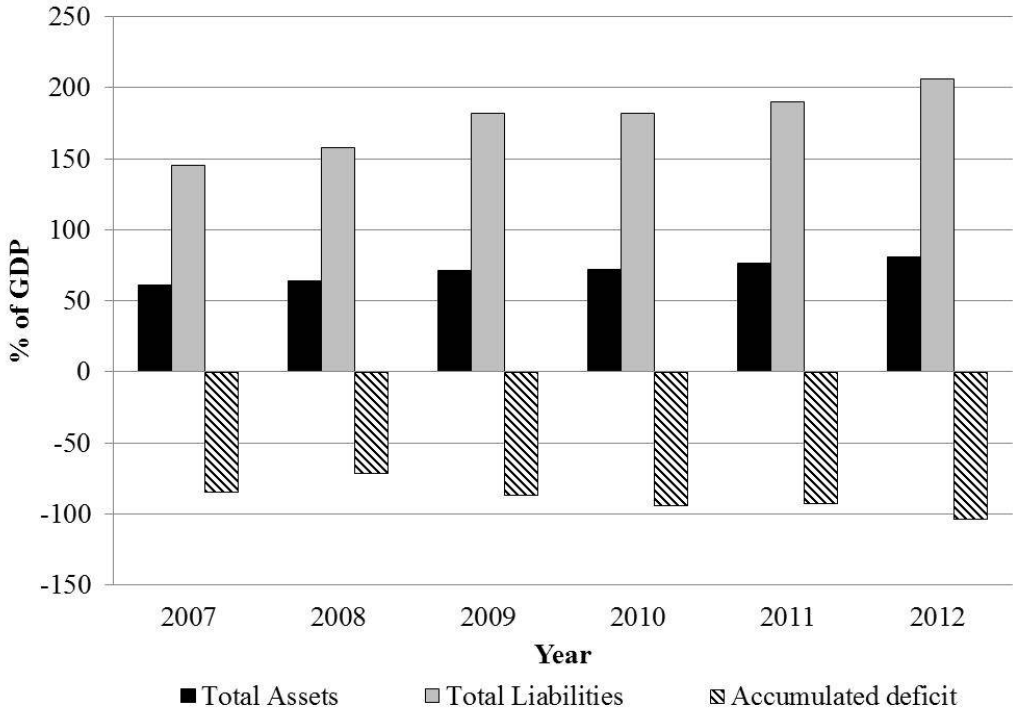
Table 4.3: Balance sheet for the Swedish pension system at 31 December each year

	2007	*2008*	*2009*	*2010*	*2011*	*2012*
Asset (% of GDP)						
Financial asset	28.7	22.1	26.6	26.8	25.1	27.0
Contribution asset	195.6	202.2	204.8	197.0	196.2	194.8
Total assets	224.4	224.2	231.5	223.8	221.2	221.8
Liabilities (% of GDP)						
Liability to pensioners	66.8	70.9	80.8	76.9	74.1	78.2
Liability to contributors	157.0	161.0	161.0	143.7	142.6	145.8
Accumulated surplus	0.6	0.6	-7.8	-9.7	3.0	4.4
Change in net worth	0.0	-8.2	-2.6	12.8	1.6	-6.6
Total liabilities	224.4	224.2	231.5	223.8	221.2	221.8
Funding, solvency and liquidity indicators						
Ratio of (in)solvency (assets/liabilities)	1.00	0.97	0.96	1.01	1.02	0.99
Degree of funding(%) (financial asset/liabilities)	12.84	9.52	11.01	12.15	11.57	12.05
Liabilities to contributors/ liabilities(%)	70.17	69.43	66.59	65.14	65.82	65.10

Own source based on Swedish Pensions Agency (2013)

The evolution of total assets, total liabilities and accumulated deficits for the Chinese PAYG pension system is given in Figure 4.1. We can see that both assets and liabilities are increasing over the period 2007-2012, but the total liabilities increased at a higher rate than total assets, causing an increase of the accumulated deficit.

Figure 4.1: Evolution of assets, liabilities and accumulated deficits for the Chinese pension system



Own source

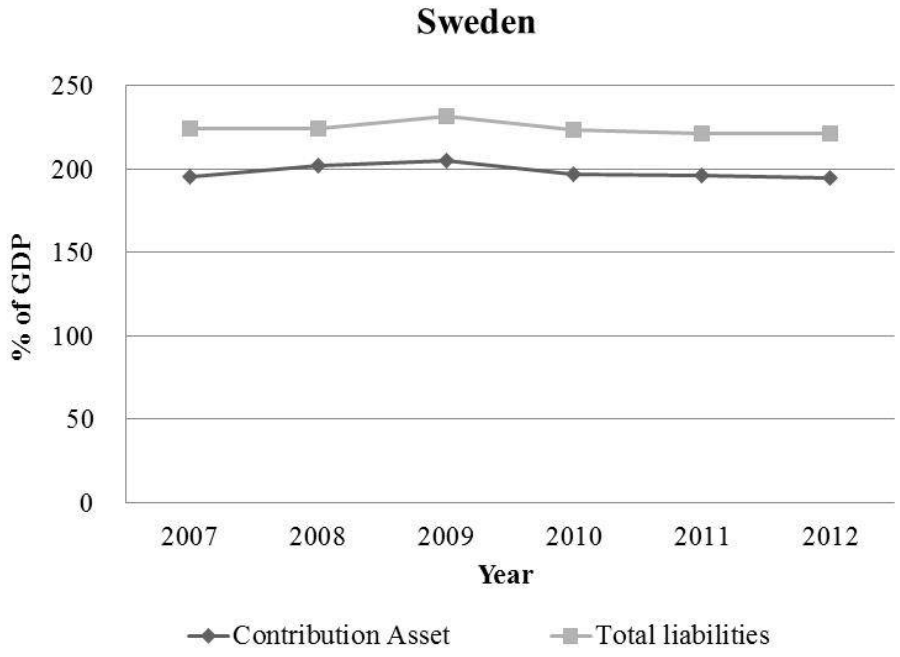
Comparison between China and Sweden

Figure 4.2 shows a comparison of the contribution asset, total liabilities, accumulated surpluses or deficits and the SR between China and Sweden from 2007 to 2012.

We can see that the gap between contribution assets and total liabilities is decreasing for Sweden in Figure 4.2a, but this gap is increasing for China and represents 130% of the GDP in 2012 in Figure 4.2b. As shown in Figure 4.2c, China accumulates a large amount of deficit which makes the SR lower than one (See Figure 4.2d) while Sweden is managing to keep a small deficit for some years and a SR always around 1[28].

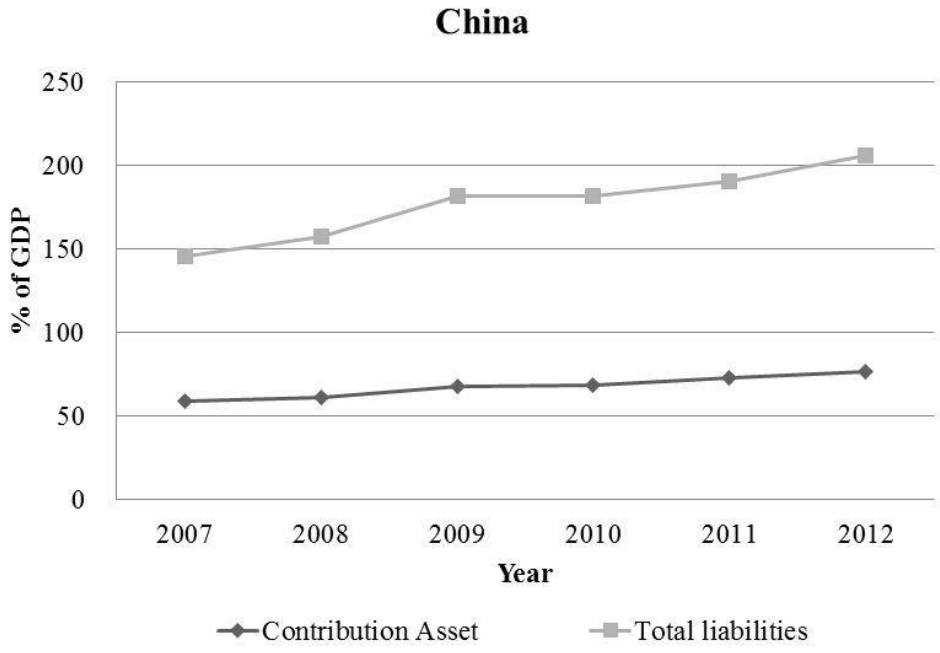
Figure 4.2: Comparison of the results between Sweden and China

(a) Contribution Asset and total liabilities for Sweden

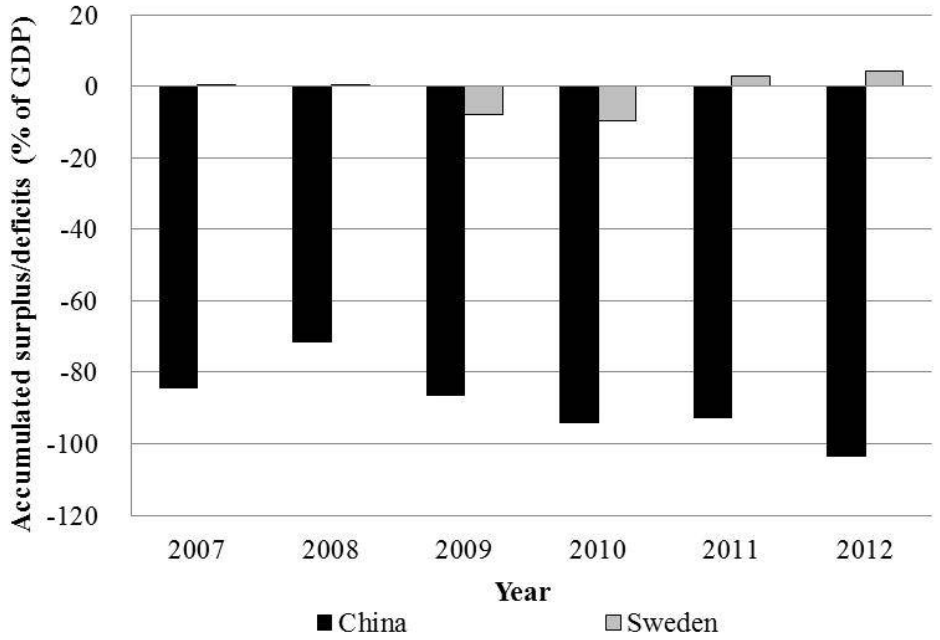


[28]In Sweden if for some reason the solvency ratio is less than 1 the ABM is triggered. This consists basically of reducing the growth in pension liability, i.e. the pensions in payment and the contributors' notional capital. See Settergren (2001).

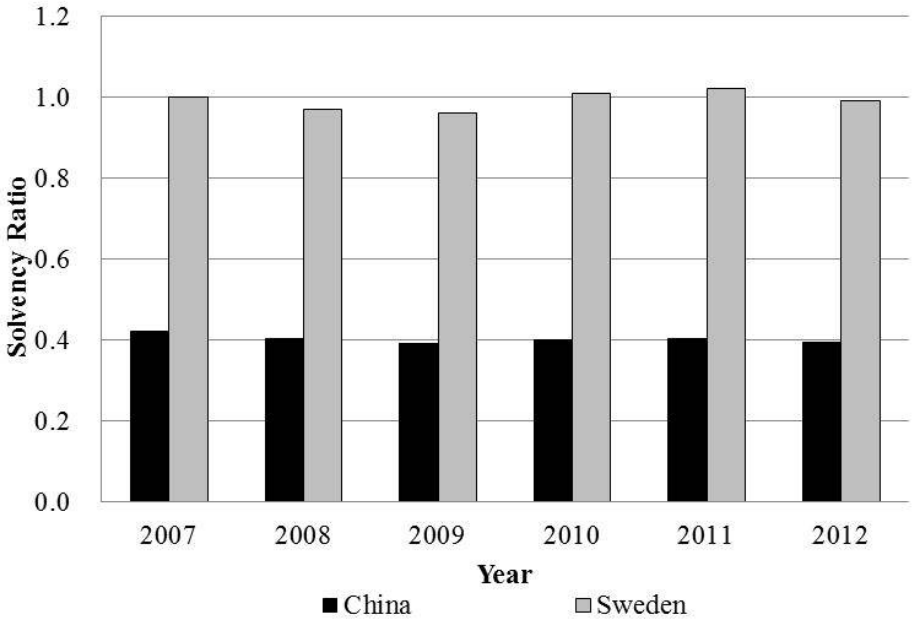
(b) Contribution Asset and total liabilities for China



(c) Comparison of accumulated surpluses or deficits between Sweden and China



(d) Comparison of SRs between Sweden and China



Sensitivity Analysis for 'More contribution years' and 'Fewer contribution years'

This subsection provides a sensitivity analysis for different numbers of contribution years. Due to the lack of accurate data for contribution years, we are interested in how the number of contribution years might affect the SR under the current rules of the Chinese pension system. The expression to calculate the total number of contribution years under different scenarios is provided in Appendix F.

Table 4.4 and 4.5 show the results of actuarial balance sheets under the scenarios of 'More contribution years', i.e. 35 years and 'Fewer contribution years', i.e. 29 years. The results show that the Chinese solvency ratio keeps quite stable under the different scenarios, that is around 0.4, which again indicates the insolvency of the system under

the different scenarios analysed.

Table 4.4: Balance sheet for the Chinese pension system at 31 December each year under 'More contribution years' scenario

Contribution Years = 35	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Asset (% of GDP)						
Financial asset	2.30	2.60	3.14	3.49	3.75	4.22
Contribution asset	60.05	62.29	69.13	70.03	73.76	77.61
Accumulated deficit	88.68	88.68	98.93	116.98	115.51	121.21
'Loss for the period'	0.00	10.26	18.04	-1.46	5.70	12.20
Total assets	151.02	163.82	189.24	189.04	198.71	215.23
Liabilities (% of GDP)						
Liability to pensioners	64.15	69.76	80.67	83.25	84.54	90.63
Liability to contributors	86.87	94.07	108.58	105.78	114.18	124.60
Total liabilities	151.02	163.82	189.24	189.04	198.71	215.23
Funding, solvency and liquidity indicators						
Ratio of (in)solvency (assets/liabilities)	0.413	0.396	0.382	0.389	0.390	0.380
Degree of funding(%) (financial asset/liabilities)	1.52	1.59	1.66	1.85	1.89	1.96
Liabilities to contributors/ liabilities(%)	57.5	57.4	57.4	56.0	57.5	57.9

Own source

Table 4.5: Balance sheet for the Chinese pension system at 31 December each year under 'Fewer contribution years' scenario

Contribution Years = 29	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*
Asset (% of GDP)						
Financial asset	2.30	2.60	3.14	3.49	3.75	4.22
Contribution asset	55.95	57.95	64.22	64.74	68.27	72.31
Accumulated deficit	76.44	76.44	85.79	102.11	101.67	105.80
'Loss for the period'	0.00	9.35	16.31	-0.44	4.13	9.24
Total assets	134.69	146.34	169.47	169.90	177.82	191.57
Liabilities (% of GDP)						
Liability to pensioners	64.15	69.76	80.67	83.25	84.54	90.63
Liability to contributors	70.54	76.58	88.80	86.65	93.28	100.94
Total liabilities	134.69	146.34	169.47	169.90	177.82	191.57
Funding, solvency and liquidity indicators						
Ratio of (in)solvency (assets/liabilities)	0.432	0.414	0.397	0.402	0.405	0.399
Degree of funding(%) (financial asset/liabilities)	1.71	1.78	1.85	2.06	2.11	2.20
Liabilities to contributors/ liabilities(%)	52.4	52.3	52.4	51.0	52.5	52.7

Own source

4.3.3 Parametric Reforms based on SR for China

The results of the Chinese actuarial balance sheets show that the current Chinese PAYG pension system is insolvent. Therefore some parametric reforms should be undertaken immediately to improve the system's solvency in the long term. If only one of the parametric measures is modified, the contribution rate (CR) would need to increase by 15%, or the retirement age would need to increase to 66, in order to achieve a SR closet to one. Obviously parametric reforms of only one decision variable taken in isolation are unfeasible in practice.

Table 4.6 shows the results of the SRs for China when two variables are modified simultaneously in the parametric reforms. We can see that if two measures were taken simultaneously, under the current replacement rate (RR), the SR would be close to 1 (i.e. 1.007) when the effective retirement age increases from 53 to 63 and the indexation of pensions decreases at an annual rate of 10%.

Table 4.6: Solvency ratio (SR) for the Chinese pension system after changes in the parametric measures

Item		RR			λ			Retirement Age		
		31%	22%	18%	0%	-10%	-20%	53	60	63
CR	=	0.393	0.539	0.649	0.393	0.455	0.539	0.393	0.613	0.790
	5%	0.533	0.758	0.938	0.533	0.626	0.758	0.533	0.946	1.372
	10%	0.703	1.046	1.346	0.703	0.841	1.046	0.703	1.497	2.742
	15%	0.914	1.444	1.963	0.914	1.119	1.444	0.914	2.590	9.869
RR	31%				0.393	0.455	0.539	0.393	0.613	0.790
	22%					0.633	0.766	0.539	0.913	1.265
	18%					0.770	0.948	0.649	1.175	1.744
λ	0%							0.393	0.613	0.790
	-10%							0.455	0.747	1.007
	-20%							0.539	0.956	1.386

Own source
Note: The SRs within the range [0.9, 1.1] are highlighted in the table.

A possibility to restore the solvency if three parametric measures were taken simultaneously securing a replacement rate of 50% would be an increase of the retirement age to 60, an increase of the CR by 6%, and at the same time a decrease in the indexation of pensions by 10%:

4.4 Analysis of Chinese Pension System based on United States' Methodology

This section shows the results of the actuarial balance indicator (AB) for Chinese pension system following the United States' methodology. A comparison with the United States' pension system is also provided together with some parametric reforms to restore the sustainability of the Chinese pension system.

4.4.1 Data and Assumptions

- Annual real wage growth rate, g, annual real indexation of pensions, λ, and projected yield rate, r, for the Chinese pension fund are assumed to keep constant at the last 20 years average rates, i.e. 7.62%, 9.13% and 3% respectively.

- The projected data on the population of China is obtained from United Nations (2012).

- The population projections under the 'Normal Scenario' follow the structure of 'Medium Variant' (Medium fertility, normal mortality, normal international migration) from United Nations (2012). Under this projection, the dependency ratio increases from 32% in 2012 to 122% at the end of the analysed period.

4.4.2 AB for China

Table 4.7 shows the calculation of AB in the 'Normal Scenario' for China and compares it with the United States over the period 2012-2087. The AB for China in the year 2012 is -39.09%, which means that the current CR in China should be immediately increased by 39.09% to make the Chinese PAYG pension system sustainable, and therefore the CR in China should be 59.09%. At the same time, the AB for the United States in 2012 is equal to -2.67%, meaning that the United States only needs to increase the CR to 15.91% to make its pension system sustainable over the next 75 years. As a result, the current Chinese PAYG pension system is quite unsustainable compared to the United States, though China will have one year more than the United States for the reserve fund to be exhausted in 2034, and the year of first deficit is 13 years later than the United States, i.e. 2025[29]. As for the year 2012, the income from contributions exceeds spending on pensions, generating a surplus of 100.4 billion RMB for the Chinese pension system.

Sensitivity Analysis for the Chinese Actuarial Balance Indicator

Table 4.8 shows the calculation of the Chinese AB under two new different demographic scenarios: 'optimistic' and 'pessimistic' scenarios. The projections under 'optimistic scenario' assume a dependency ratio constant and equal to 32% as in the current year 2012 (beginning of the analysis). While the projections under the 'pessimistic

[29]In 2025 the income from contributions is 356.9 billion RMB while the spending on pensions is 392.5 billion RMB in China.

Table 4.7: Elements of the 75-year actuarial balance 2012-2087 for China and United States. Present value at January 2012.

	Items	China (RMB in billions)	US (Dollar in billions)
1	Income from contributions	717,977	45,198
2	Spending on pensions	2,027,633	56,477
3=1-2	Initial deficit	-1,309,656	-11,278
4	Trust fund assets at start of period	2,190	2,678
5=3+4	Open group unfunded obligation	-1,307,466	-8,601
6	Ending target trust fund	95,982	501
7=5-6	Results for the period	-1,403,448	-9,101
8	Aggregate contribution bases	3,589,883	341,465
9=(1+4)/8	Summarized income rate	20.06%	14.02%
10=(2+6)/8	Summarized cost rate	59.15%	16.69%
11=9-10	Actuarial Balance (AB)	-39.09%	-2.67%
12	Year of first deficit	2025	2012
13	Reserve fund exhausted (year)	2034	2033

Own source. The result of United States is from The Board of Trustees, Federal Old-Age And Survivors Insurance and Federal Disability Insurance Trust Funds (2012).

scenario' assume that the population projections follows a 'low variant' (low fertility, normal mortality, normal international migration) structure of United Nations (2012). This assumption will give us a pessimistic scenario with the number of contributors decreasing in the next 75 years, giving a dependency ratio of 198% at the end of the period.

Table 4.8: Elements of the 75-year actuarial balance 2012-2087 for China under different scenarios. Present value at January 2012. *Unit: RMB in billions*

	Items	Optimistic	Normal	Pessimistic
1	Income from contributions	948,870	717,977	678,039
2	Spending on pensions	1,092,022	2,027,633	2,169,667
3=1-2	Initial deficit	-143,152	-1,309,656	-1,491,628
4	Trust fund assets at start of period	2,190	2,190	2,680
5=3+4	Open group unfunded obligation	-140,962	-1,307,466	-1,488,948
6	Ending target trust fund	57,170	95,982	112,452
7=5-6	Results for the period	-198,132	-1,403,448	-1,601,400
8	Aggregate contribution bases	4,744,349	3,589,883	3,390,194
9=(1+4)/8	Summarized income rate	20.04%	20.06%	20.08%
10=(2+6)/8	Summarized cost rate	24.22%	59.15%	67.32%
11=9-10	Actuarial Balance (AB)	-4.18%	-39.09%	-47.24%
	Dependency Ratio at year 2087	32%	122%	198%

Own source

In the 'optimistic scenario', when the assumed demographic structure is kept constant for the next 75 years as in 2012, the AB for China is -4.18%, which means the Chinese pension system is not sustainable even in the case of the 'optimistic scenario'. In the 'pessimistic scenario', the AB for China is equal to -47.24%. Although the AB changes a lot under different scenarios, the summarised income rate is more or less the same, thus the major change of AB comes from the summarised cost rate, i.e. the present value of future pensions needed to be paid and the end target pension fund as a percentage of the present value of contribution bases.

Since the ageing problem is one of the most important problems for the future of the Chinese PAYG pension system, this sensitivity analysis only considers the different scenarios for demographic structure changes. Further research could focus on macroeconomic variable changes, consideration of which is beyond the scope of this chapter[30].

4.4.3 Parametric Reforms based on AB for China

Since the AB for China indicates that the current Chinese PAYG pension system is not sustainable under all the scenarios analysed, some parametric reforms need to be implemented immediately to make the system sustainable in the future. If only one parametric measure was undertaken, then the CR should be increased by 39.09% to restore the sustainability of the system, as shown in Table 4.7. Another possibility would be an increase in the retirement age to 66.

However, two parametric measures could be undertaken simultaneously, to make a relatively smooth reform, as shown in Table 4.9. We can see that the Chinese pension system would be sustainable (AB = 4.7%) when the CR increases by 20% and the indexation of pensions decreases at an annual rate of 1%.

[30]To give just a few examples so as not to go into great length, the AB would be -18.83% if the values for salary growth and indexation on pensions were 5 percentage points lower, i.e. 2.63% and 4.13% respectively.

Table 4.9: Actuarial balance indicator (AB) for the Chinese pension system after changes in the parametric measures

Item		RR			λ			Retirement Age		
		31%	25%	20%	0%	-1%	-2%	62	64	66
CR	=	-39.0%	-27.7%	-18.1%	-39.0%	-15.3%	-1.4%	-21.7%	-7.7%	1.3%
	10%	-29.1%	-17.7%	-8.1%	-29.1%	-5.3%	8.6%	-11.7%	2.3%	11.3%
	15%	-24.1%	-12.7%	-3.1%	-24.1%	-0.3%	13.6%	-6.7%	7.3%	16.3%
	20%	-19.1%	-7.7%	1.9%	-19.1%	4.7%	18.6%	-1.7%	12.3%	21.3%
RR	31%				-39.0%	-15.3%	-1.4%	-21.7%	-7.7%	1.3%
	25%				-27.7%	-8.4%	2.7%	-13.6%	2.3%	4.9%
	20%				-18.1%	-2.7%	6.2%	-6.9%	2.2%	7.9%
λ	0%							-21.7%	-7.7%	1.3%
	-1%							-4.9%	3.6%	8.9%
	-2%							4.9%	10.1%	13.3%

Own source
Note: Highlighted boxes are the results of AB for China within the range [-8%, 8%].

4.5 Summary

Restoring the sustainability of a PAYG pension system is on the agenda for most governments and China is no exception. This chapter uses two actuarial balance methodologies to evaluate the real situation of the sustainability of the Chinese PAYG pension system in the urban area over the period 2007-2012.

The actuarial balance sheet for the Chinese pension system, based on the verifiable facts, shows that the total liabilities of the current Chinese PAYG pension system are more than double its assets, which implies that the system is insolvent.

The United States' model, which takes into account the demographic and economic projections, shows that the current contribution rate in China should be immediately

increased by 39.09% to make the Chinese pension system sustainable in the next 75 years. Even in the optimistic scenario, when the demographic structure is kept constant, the Chinese pension system is not sustainable in the long term.

As a result, no matter under which model, the Chinese pension system shows a weak position of financial health and the results presented indicate that the need to adopt measures to restore solvency/sustainability is urgent.

This chapter also provides the advice on some parametric reforms to adjust the system on the road to long-term financial stability. The reforms presented are linked to the solvency ratio (SR) for the case of the Swedish methodology and the actuarial balance indicator (AB) for the United States' model.

The absence of an actuarial balance in the case of China also produces a 'mirage effect' and reduces the importance of future cash deficit because currently the income from contributions exceeds the expenditure on pensions. This generates a surplus of 100.4 billion RMB in the year 2012 for the Chinese pension system and might delay effective measures being taken to restore solvency/sustainability to the system.

Future research is focused on making the reforms (in this case also called ABM) more applicable through smoother changes of the key variables such as the contribution rate, retirement age and indexation of pensions. The methodology, based on non-linear optimization models, calculate an optimal paths of these key variables to restore the sustainability of the system. It is remarkable that Pozen (2013) stated that the

relaxation of the one-child policy would restore the sustainability of the system. With this in mind, using the cohort component method and the optimization model, we will be able to assess the consequences of the one-child policy and other different fertility policies on the sustainability of the Chinese pension system.

Chapter 5

Implications of One-Child Policy

In 1979, the Chinese government introduced the one-child policy with the aim of controlling the country's rapid population growth. This policy will lead to deficits in the Chinese pay-as-you-go (PAYG) pension system since the country's individuals are living longer and having fewer children. This chapter analyses the impact of different demographic policies on the long-term sustainability of the Chinese PAYG pension system. Using the cohort component projection method, we forecast three different population structures and design automatic balancing mechanism (ABM) to restore the financial equilibrium of the system. The main finding is that, in all the scenarios studied, there is an urgent need to introduce some mechanisms to guarantee the long-term sustainability of the Chinese pension system.

5.1 Introduction

Since the foundation of the People's Republic of China on October 1st 1949, China has experienced significant demographic changes. After an initial period of very high fertility, total fertility rates dropped from 6.11 in 1950 to 3.01 in 1979 (See Figure 3.3) when the one-child policy was first implemented with the aim of controlling rapid population growth (United Nations, 2015).

The consequences of the one-child policy on the Chinese economic growth have been widely discussed during the last three decades after its implementation. The contribution to the economic growth after its first implementation has been confirmed by some authors. McElroy and Yang (2000) and Li et al. (2005) state that the one-child policy, by means of a reduction in the fertility rates and a control in the population growth, has contributed to the economic growth and has improved living standards for many Chinese families. Following this line of argument, Li and Zhang (2007) also find that high birth rates have a negative impact on the economic growth, and thus the one-child policy is indeed growth enhancing. However, some problems have emerged recently after 30 years implementation of the policy. For example, the one-child policy has led to the decreasing number of the working-age population, and hence caused the labour shortage in the market. Thus, some authors raise the concerns about the compatibility of the one-child policy with the country's long-term economic growth in the future. Bloom and Williamson (1998) claim that the previous economic growth brought about by the one-child policy would be dissipated by the rising volume of elderly individuals

in the future. Also, Howden and Zhou (2014) state that China is currently facing a serious labour shortage, with the first working population decrease occurring in 2012, and this is not compatible with its objective of economic advancement.

The one-child policy has become increasingly unpopular due to both the country's ageing population and the shortage in the labour market. For these reasons, in December 2013 the one-child policy was adjusted to promote the long-term balanced development of the population in China.

The population structure of a country has a major impact on the sustainability of a PAYG pension system where the current active workers pay the benefits for the current pensioners. Thus, a decrease in the number of contributors and an increase in the number of pensioners, i.e. an increase in the old-age dependency ratio would lead to deficits in the Chinese pension system.

China has already taken some steps to guarantee the long-term sustainability of the pension system, such as, introducing longevity insurance annuities and decreasing the replacement rates (RR). Also, an increase in the retirement age from 50 (for women) and 60 (for men) to 65 for both sexes is being considered, and the introduction of an NDC scheme has recently been proposed. However, Cai and Du (2015) and Howden and Zhou (2014) argue that these actions may be insufficient to deal with the labour shortage and ageing problem faced by the Chinese population.

This chapter aims to fill a gap in the literature by investigating the consequences of

fertility policies on the long-term sustainability of the Chinese urban PAYG pension system for old-age contingency. With this aim in mind, we analyse the sustainability of the Chinese pension system under three different demographic scenarios–'The one-child policy implemented in 1979', 'Relaxation of the one-child policy implemented in 2013' and 'No implementation of any fertility policy'. Following the paper by Godínez-Olivares et al. (2016a), we calculate the optimal paths (also called ABM) of the main variables (contribution rate, retirement age and indexation of pensions) that make the pension system sustainable under the three demographic scenarios during the 75-year period from 2012 to 2087. An analysis of the optimal values of the main variables will provide us with a clear view of the impact of different demographic policies on the sustainability of the Chinese pension system.

The remainder of this chapter is organized as follows. In Section 5.2 we describe the history and evolution of the fertility policies in China. In Section 5.3, we describe the cohort component method for population projection and calculate the population pyramids under the three demographic scenarios. In Section 5.4, following the methodology used by Godínez-Olivares et al. (2016a), we calculate the optimal paths for the contribution rate, retirement age and indexation of pensions under the different demographic structures. Section 5.5 provides the conclusions and makes recommendations on reforms under the different population scenarios.

5.2 History of One-Child Policy

The People's Republic of China was founded on October 1st 1949, when the communists came to power. In order to consolidate the power and build a stronger socialist state, the president Mao Zedong, with the idea that more people meant additional numbers to fight against capitalism, encouraged people to have more children. As a result, the total fertility rate, as shown in Figure 3.3, reached the value of 6.11 in the 1950s and the population nearly doubled during the period 1950-1970 according to United Nations (2015).

In the early 1970s, the Chinese government began to control its rapid population growth with the 'Later, Longer and Fewer' program that encouraged people to get married later, have longer intervals between births and have fewer children. However, this program did not reach its goal of reducing population growth rate as was originally intended. Therefore, the Chinese government formally introduced the one-child policy as a family planning policy which directly targets the number of children per family in 1979[31]. As a result of the implementation of this policy, the total fertility rate fell from 3.01 in 1979 to 1.55 in 2010 as shown in Figure 3.3.

In December 2013, since the one-child policy was causing a continuing decrease in the

[31] This program included both incentives and penalties to assure that couples produced only one child. In addition to free contraceptives, abortions and sterilizations, families that followed the policy could get an allowance until the child reached the age of 14. Also the child had the priority access to schools, college, employment, healthcare and housing. The penalties, including steep fines, were imposed on couples that had a second child. See Banister (1987), Chen and Kols (1982), and Lin and Zhou (1984) for more detailed information.

size of the working-age population, the Chinese central government decided to relax[32] partially the one-child policy. This partial relaxation of the policy allowed families to have two children if one parent, rather than both parents, was an only child in his/her family.

On October 29th 2015, with the aim of dealing with the ageing population, the Chinese central government went further and decided to abolish the one-child policy, now allowing all families to have two children.

5.3 Population Projections under Different Demographic Scenarios from 2012 to 2087

In this section, we introduce the cohort component method and apply it to calculate population pyramids in China over the period 2012-2087 under the following three demographic scenarios: 'One-child policy is implemented as in 1979', 'One-child policy is adjusted as in 2013' and 'No fertility policy has implemented since 1979'.

[32] See the 'Standing Committee of the National People's Congress Resolution on the Adjustment and Improvement of Fertility Policy' from The National People's Congress of the People's Republic of China (2013)

5.3.1 The Cohort Component Method

The cohort component method has been widely used because it provides a flexible and powerful approach for population projection[33]. It provides projections not only of total population but also of the demographic composition and individual components of growth (Smith et al., 2013). The earliest applications of this method can be dated back to 1895 for United Kingdom (Bowley, 1924; Cannan, 1895), and 1928 for United States (Whelpton, 1928). The Office for National Statistics in countries such as United Kingdom, Japan, Canada, Spain and the United States, inter alia, also use this method to forecast population size and structure.

Mathematically, we calculate total population at year $t+1$, $N(t+1)$, as follows:

$$N(t+1) = N(t) + B(t) - D(t) + M(t) \tag{5.1}$$

Where $N(t)$ is the total number of population at year t; $B(t)$ is the total number of new births during year t; $D(t)$ is the number of deaths during year t, and $M(t)$ is the net number of migrants during year t. The illustration of the cohort component method is provided in Appendix G.

[33] A cohort can be defined as a group of people who experience the same demographic event during a particular period of time and who may be identified at later dates on the basis of this common experience (Shryock et al., 1973).

5.3.2 Main Data and Scenarios Analysed

- Survival rates and net migration rates are both obtained from United Nations (2015)[34].

- Scenario 1: Fertility rates under the one-child policy implemented as in 1979 are obtained from United Nations (2015), with the projected total fertility rates for China varying from 1.55 in 2012 to 1.81 in 2087, as shown in Figure 5.1 (Scenario 1)[35].

- Scenario 2: Fertility rates follow the one-child policy adjusted in 2013. The total fertility rates are assumed to be equal to 2 (See Figure 5.1: Scenario 2)[36].

- Scenario 3: It is assumed that no fertility policy has been in place since 1979, and therefore annual total fertility rates are assumed to be constant and equal to 3.01, i.e. the value of the total fertility rate in 1979 just before the one-child policy was implemented (See Figure 5.1: Scenario 3).

- For an easy comparison between the one-child policy and its adjustment, the

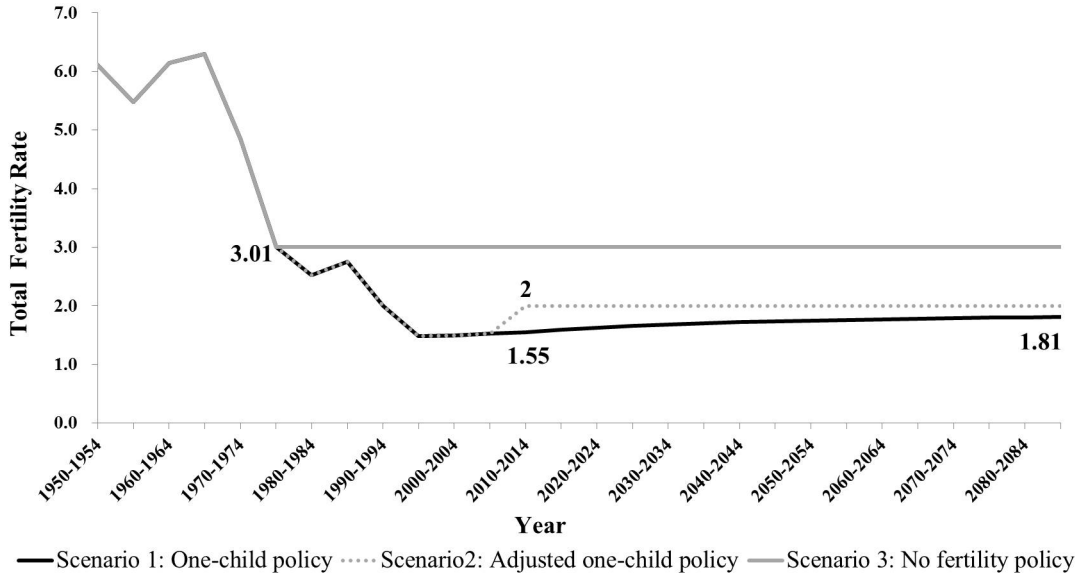
[34]Data from United Nations is used due to the fact that the Chinese Ministry does not carry out projections on survival rates, fertility rates and migration rates. The survival rates is obtained from the life table (United Nations, 2015), which takes into account the infant mortality. Data on the survival rates are provided in Appendix H.

[35]United Nations (2015) considers the one-child policy in their projections. The one-child policy has been relaxed since 2013, thus this scenario is unrealistic to be kept in the future. However, our aim in this chapter is to compare the different demographic scenarios, and to study the consequences of the one-child policy.

[36]Our aim is not to accurately forecast the future population in China but to analyse how different fertility policies might affect the sustainability of the system. Therefore, the fertility rate assumed in Scenario 2 is exactly equal to the target value of the adjusted policy.

population pyramids are provided taking 2012 as an initial point (just before the adjusted one-child policy was introduced).

Figure 5.1: Projected total fertility rates under three demographic scenarios, 2012-2087



Own source

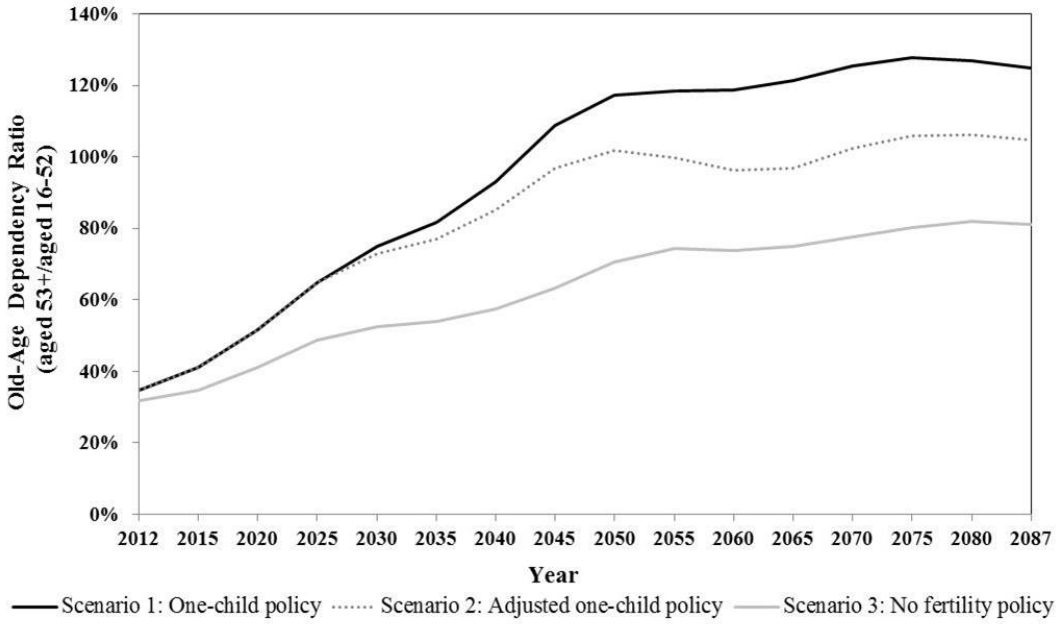
5.3.3 Results

Figure 5.2 shows the projections of old-age dependency ratios over the period 2012-2087 under different demographic scenarios, when the old age population is above the effective retirement age of 53 and the entry age to the labor market starts at 16. In 2012 the dependency ratio is 34.81% for both Scenario 1 and Scenario 2, i.e. 2.87 contributors finance one pensioner, whereas its value is 31.84% in the case of Scenario 3, i.e. 3.14 contributors finance one pensioner.

In 2087, the old-age dependency ratios under Scenario 1 and Scenario 2 are equal to

124.94% and 104.77% respectively, i.e. there will be more pensioners than contributors at the end of the period of study, while its value is lower (81.01%) if no policy had been implemented (Scenario 3).

Figure 5.2: Old-age dependency ratios (aged 53+/aged 16-52) under different demographic scenarios, 2012-2087

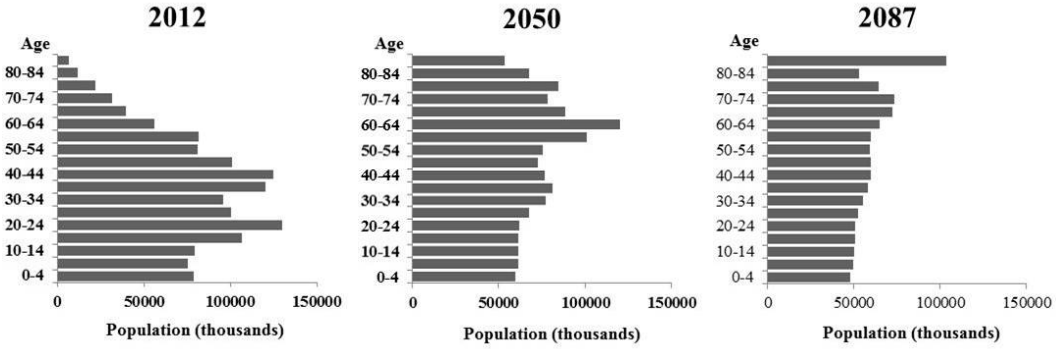


Own source

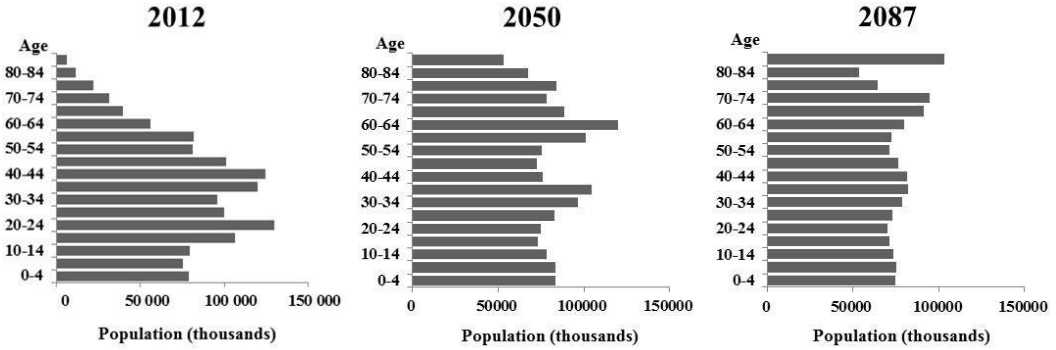
We can see that for all the demographic scenarios considered, the old-age dependency ratio will dramatically increase over the period 2012-2087, and this will have a negative impact on the sustainability of the Chinese PAYG pension system. Figure 5.3 shows the population pyramids under the three demographic scenarios in 2012, 2050 and 2087. We can see that the number of the old-age population are increasing more rapidly under Scenario 1 than under the other two scenarios.

Figure 5.3: Evolution of population pyramids under different demographic scenarios

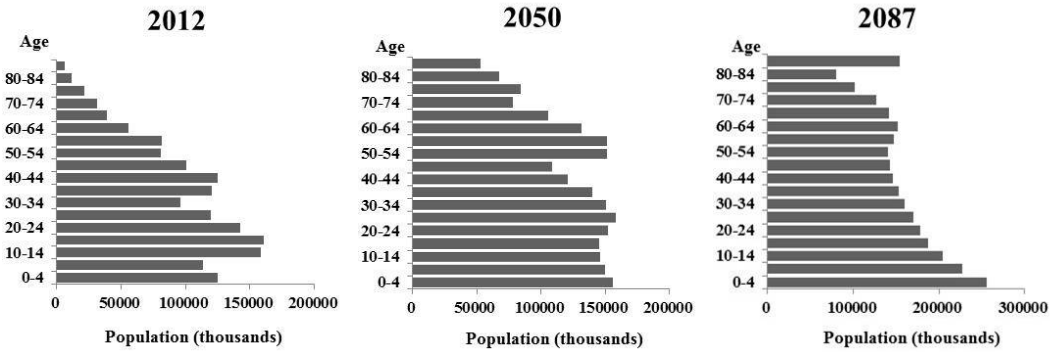
(a) Scenario 1: One-child policy



(b) Scenario 2: Adjusted one-child policy



(c) Scenario 3: No fertility policy



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5.4 Automatic Balancing Mechanism (ABM) to Restore the Sustainability

PAYG pension systems operate financially through the current active workers paying contributions which are used to pay pensions to the current pensioners. It is clear that the increased longevity of pensioners and decreases in the size of the working population will lead to PAYG pension systems becoming unsustainable. This is a worldwide problem, and many countries have already carried out some parametric reforms. As noted earlier, China has also tried to solve this ageing problem by decreasing the replacement rates and increasing the retirement age[37].

In this context, automatic balancing mechanism (ABM), are defined as a set of predetermined measures established by law to be applied immediately as required according to an indicator that reflects the financial health of the system (Vidal-Meliá et al., 2009). Countries, such as Sweden, Germany and Japan, amongst others, have already set up an ABM with the aim of re-establishing the financial equilibrium of their systems[38]. This section follows the theoretical ABM introduced by Godínez-Olivares et al. (2016a) to analyse the consequences of different demographic policies on the sustainability of the Chinese pension system.

[37] See Chomik and Piggott (2015) and Hujo and Cook (2012) for pension reforms in Asian countries. For pension reforms in the world, please refer to Holzmann (2013).

[38] See Vidal-Meliá et al. (2009, 2010) and OECD (2012) for more details on ABM.

5.4.1 Mechanism

This section introduces the ABM from Godínez-Olivares et al. (2016a) to restore not only the financial sustainability of the PAYG pension system in the long term but also the liquidity on an annual basis[39].

This mechanism identifies the optimal paths of the three key decision variables (contribution rate, c_t , retirement age, $x_t^{(r)}$, and indexation of pensions, λ_t) while minimizing the net present value of the buffer fund, F_t , subject to some constraints.

The buffer fund is calculated as:

$$F_t = (1 + J_t)F_{t-1} + c_t W_t(g_t, x_t^{(r)}) - E_t(g_t, x_t^{(r)}, \lambda_t) \tag{5.2}$$

where $W_t(g_t, x_t^{(r)})$ is the total contribution base[40] paid at t that depends on the growth of salaries, g_t, and the retirement age, $x_t^{(r)}$; $E_t(g_t, x_t^{(r)}, \lambda_t)$ is the total expenditure on pensions at t that depends on the growth of salaries, g_t, the retirement age, $x_t^{(r)}$, and the indexation of pensions, λ_t; c_t is the contribution rate at t; J_t is the return of the fund at t.

Lower and upper bounds, $c_{min}, x_{min}^{(r)}, \lambda_{min} \in R$, and $c_{max}, x_{max}^{(r)}, \lambda_{max} \in R$, respectively, are imposed in order to avoid unrealistic values in the key variables of the pen-

[39]This paper extends the optimization model developed by Godínez-Olivares et al. (2016b) which focused only on the liquidity of the system in a 20-year time horizon.

[40]The total contribution base is defined as the total wages of the working population.

sion system. Also, smooth constraints are set as $c_{1\triangle} \leq \frac{c_{t+1}}{c_t} \leq c_{2\triangle}$; $x_{1\triangle}^{(r)} \leq \frac{x_{t+1}^{(r)}}{x_t^{(r)}} \leq x_{2\triangle}^{(r)}$; $\lambda_{1\triangle} \leq \frac{\lambda_{t+1}}{\lambda_t} \leq \lambda_{2\triangle}$ to prevent jumps in optimal paths of the contribution rate, age of retirement and indexation of pensions respectively. $c_{1\triangle}, c_{2\triangle}, x_{1\triangle}^{(r)}, x_{2\triangle}^{(r)}, \lambda_{1\triangle}, \lambda_{2\triangle} \in R$.

The liquidity[41] constraint is set as $F_t \geq 0$, for all t, i.e. no deficit is allowed in the Chinese pension system.

The ABM is defined as the following optimization problem:

$$
\begin{aligned}
&min_{c_t, x_t^{(r)}, \lambda_t} \sum_{t=0}^{T} \frac{F_t(c_t, g_t, x_t^{(r)}, \lambda_t, J_t)}{(1+\delta)^t} \\
&s.t. = \begin{cases}
c_{min} \leq c_t \leq c_{max}; \\
x_{min}^{(r)} \leq x_t^{(r)} \leq x_{max}^{(r)}; \\
\lambda_{min} \leq \lambda_t \leq \lambda_{max}; \\
c_{1\triangle} \leq \frac{c_{t+1}}{c_t} \leq c_{2\triangle}; \\
x_{1\triangle}^{(r)} \leq \frac{x_{t+1}^{(r)}}{x_t^{(r)}} \leq x_{2\triangle}^{(r)}; \\
\lambda_{1\triangle} \leq \frac{\lambda_{t+1}}{\lambda_t} \leq \lambda_{2\triangle}; \\
F_t \geq 0.
\end{cases}
\end{aligned}
\tag{5.3}
$$

where $\delta > 0$ is the discount rate.

[41] Liquidity is the short run financial equilibrium, i.e. each year's contribution is greater than each year's expenditure in the pension system.

5.4.2 Data and Assumptions

- Data on the number of participants in the Chinese contributory PAYG pension system in urban areas is obtained from Human Resources and Social Security Statistics Bulletin 2012 (Ministry of Human Resources and Social Security of the People's Republic of China, 2012a).

- Data on the average salary is obtained from National Bureau of Statistics of the People's Republic of China, and its value in 2012 is equal to 47,593 RMB/year. The information on wage distribution by age group is taken from the Ministry of Human Resources and Social Security of the People's Republic of China. Annual real wage growth rate, g_t , is assumed to remain constant and equal to the average rates of the last 20 years, i.e. 7.62%. The initial contribution rate, c_t, for the Chinese contributory PAYG pension system in the urban area is 20%, and it is paid entirely by the employer.

- Data on the average monthly pension is from National Social Security Fund Report 2012 (Ministry of Human Resources and Social Security of the People's Republic of China, 2012b), and its value is equal to 1,721 RMB/month (20,652 RMB/year). The initial pension is equal to 61% of the average salary in the Chinese PAYG pension system, i.e. the replacement rate is equal to 61%. The initial revaluation of pension in payments, λ_t , is equal to the average rates of the last 20 years, i.e. 9.13%. The initial effective retirement age in China is 53.

- Data on the initial amount of buffer fund is from National Social Security Fund Report 2012. The growth rate of the pension fund, J_t, is assumed to be 3% which is equal to the 1-year fixed-term deposit rate given by The People's Bank of China[42]. The discount rate, δ, is also equal to 3%[43].

- The lower bounds of the contribution rate, retirement age, and indexation of pensions are equal to 20%, 53, and -10% respectively, whereas the upper bounds are set respectively as 65%, 70, and 10%, in the case of only one decision variables is modified. While three variables are modified simultaneously, the lower bounds are given by 20%, 53, and 0% respectively, and upper bounds are 30%, 60, and 10% respectively.

- The maximum increase for contribution rate and retirement age in each year is assumed to be 2.5% and 6 months, whereas the minimum decrease for pension in payment is set to be -1%, in the case of only one decision variable is modified. The constraints are assumed to be 2.5%, 3 months and -0.5% respectively when three variables are modified simultaneously.

5.4.3 Results

This subsection presents the results of the optimal paths for the key decision variables under the different demographic scenarios for China. First, we show the results when

[42]The buffer fund is invested mostly in the bank with an interest rate equal to 3% in 2012.

[43]The discount rate is equal to 3% as the 1-year fixed-term deposit rate provided by The People's Bank of China, which is taken as a risk-free rate.

only one decision variable is modified. Second, the results when three parameters are modified simultaneously are shown. We also carried out a sensitivity analysis for the value of return rate of buffer fund (J_t), and the replacement rate (RR).

ABM with Only One Modified Decision Variable

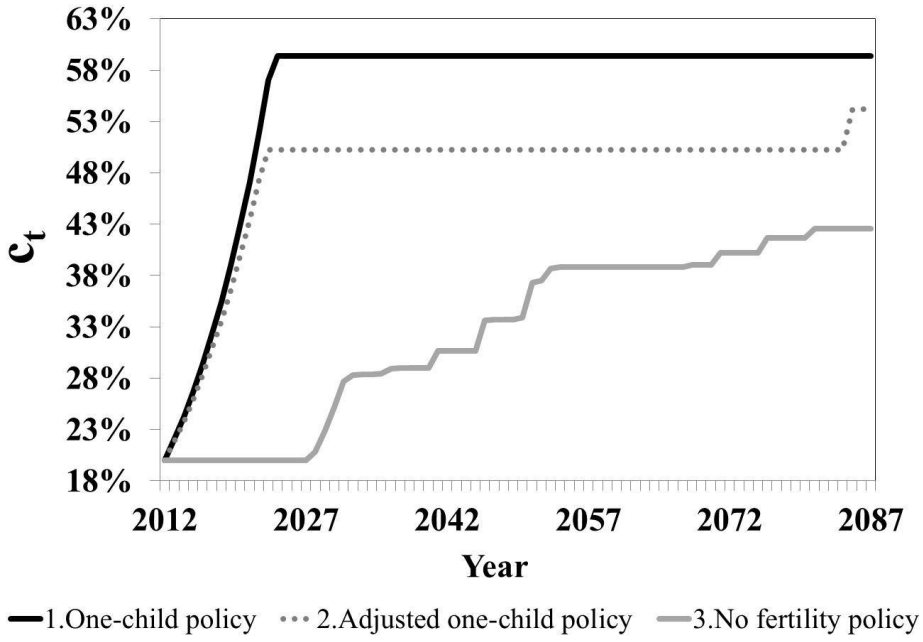
As shown in Figure 5.4a, if the contribution rate is the only decision variable, it would need to increase to 59.36% in 2087 under Scenario 1. Its value would stabilize at 42.53% under Scenario 3 whereas it would need to increase to 54.55% under Scenario 2.

Figure 5.4b shows that the retirement age stabilizes at 65.90 under Scenario 2 whereas its value would need to increase to 67.89 in the case of Scenario 1. If the indexation of pensions was the only decision variable, as shown in Figure 5.4c, the pensions in payment would need to decrease at an annual rate of 3% from 2025 to the end of the period of study under Scenario 1. We note that 62 years of negative indexation at 3% p.a would lead to an 84% decrease in the size of the pension.

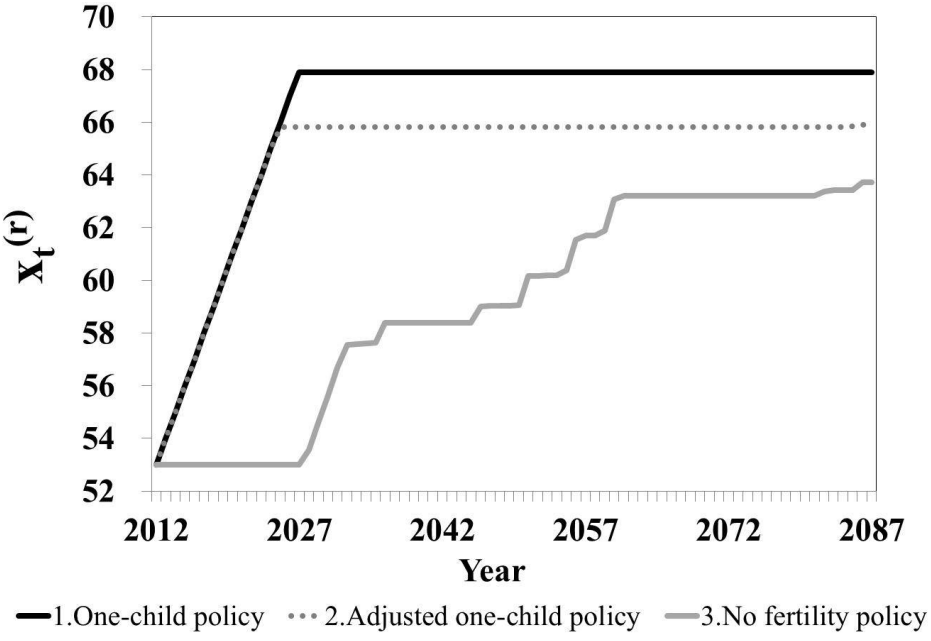
Thus, we see that the measures to restore the sustainability of the Chinese pension system when taking in isolation are quite severe. Therefore, a more gentle combination involving the contribution rate, retirement age and indexation of pensions simultaneously might be more applicable and not so harsh towards the participants in the system.

Figure 5.4: Optimal paths of key decision variables to restore the sustainability of the Chinese PAYG pension system, with only one modified variable, 2012-2087

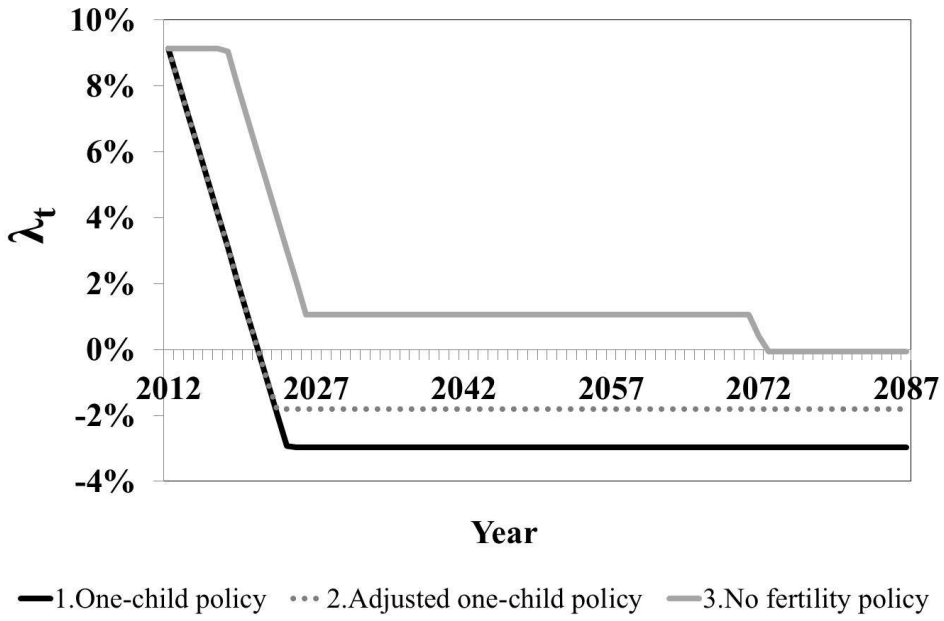
(a) Contribution rate, c_t



(b) Retirement age, $x_t^{(r)}$



(c) Indexation of pensions, λ_t



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ABM with the Three Decision Variables Modified Simultaneously

Under population structure in Scenario 1, as shown in Figure 5.5, the contribution rate stabilizes at 26.24% whereas the age of retirement and indexation of pension reach the values 57.54 and 3% respectively at the end of the time horizon.

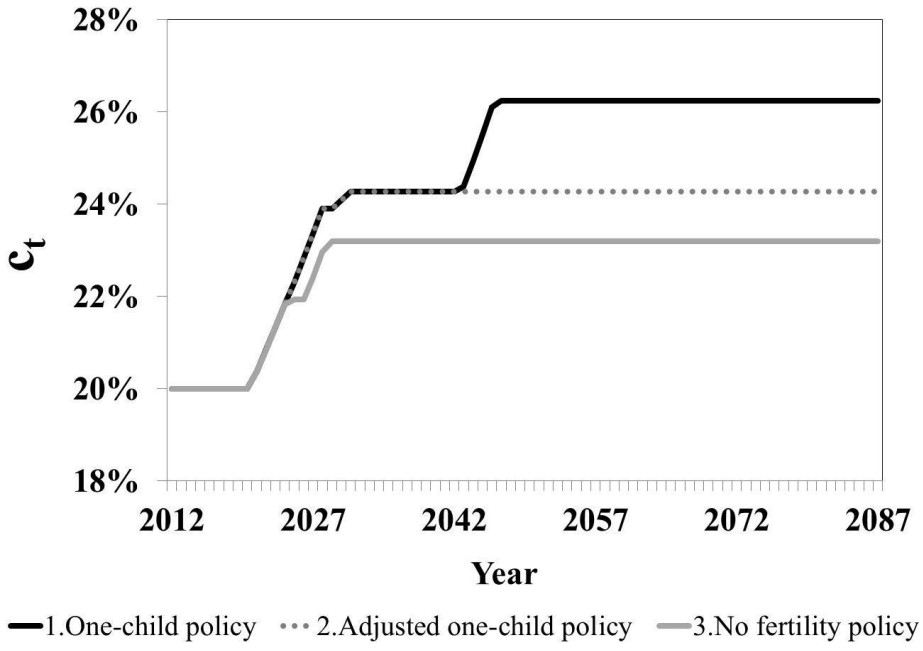
Even in the case of Scenario 3, the variables still need to be modified to guarantee the financial sustainability of the Chinese pension system in the long run. In this case, the contribution rate and retirement age would need to increase to 23.20% and 55.45 respectively, while the indexation of pension decreases to 3.70%.

As shown in Figure 5.5d, the value of the buffer fund always remains positive due to

the liquidity constraint imposed in our minimization problem, i.e. the system always need to have enough money to cover the expenditure on pensions on an annual basis. In the case of the adjusted one-child policy (Scenario 2), the value of the fund increases rapidly towards the end of the projection period as this policy does not have an immediate impact while the decision variables are modified from the beginning of the time horizon[44].

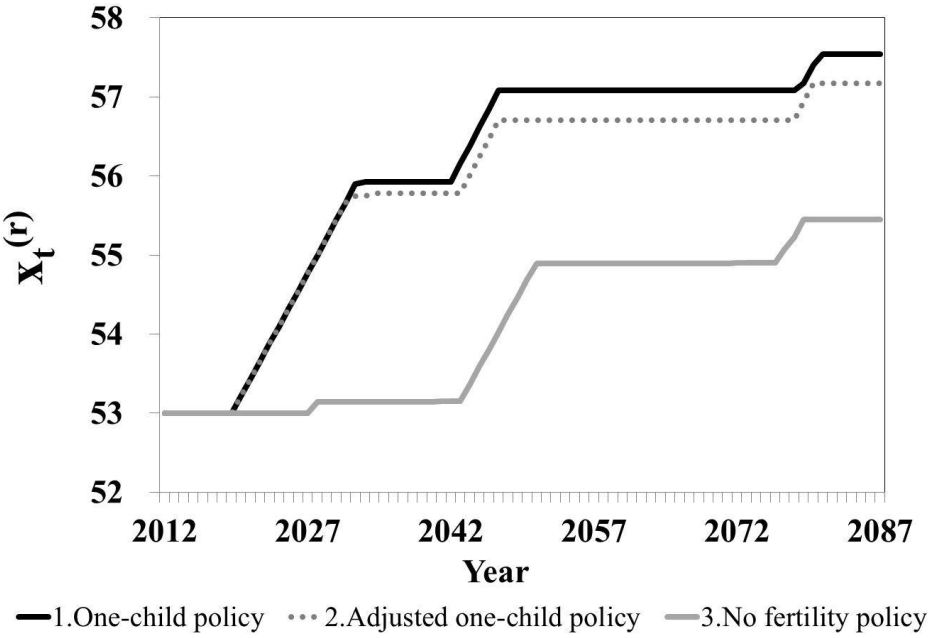
Figure 5.5: Optimal paths of key decision variables to restore the sustainability of the Chinese PAYG pension system, with three variables modified simultaneously, 2012-2087

(a) Contribution rate, c_t

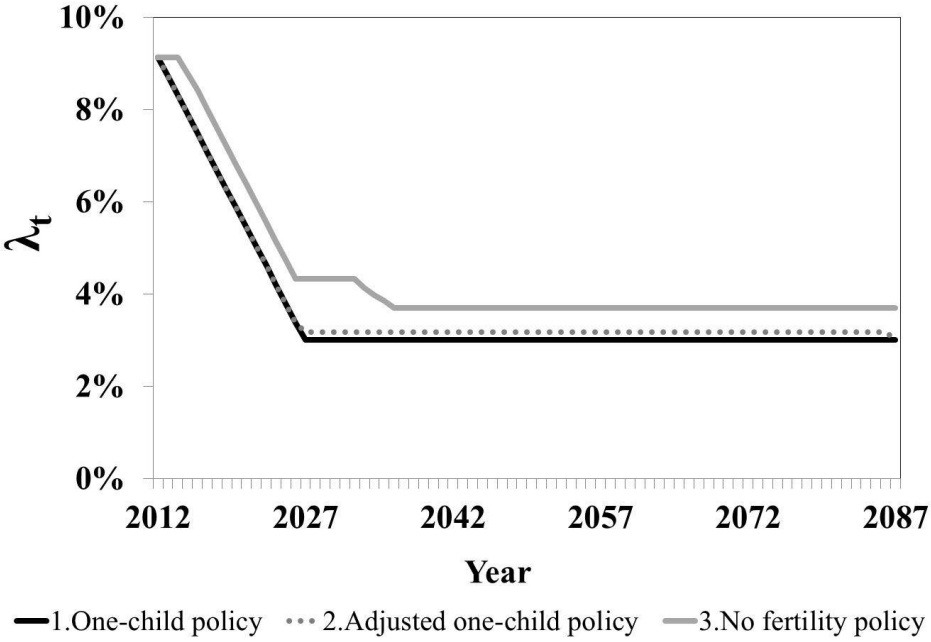


[44]This is due to the asymmetric design of the mechanism where changes in the decision variables only happen to face adverse demographic and economic risks, i.e. any surplus that might arise at some point is maintained in the system.

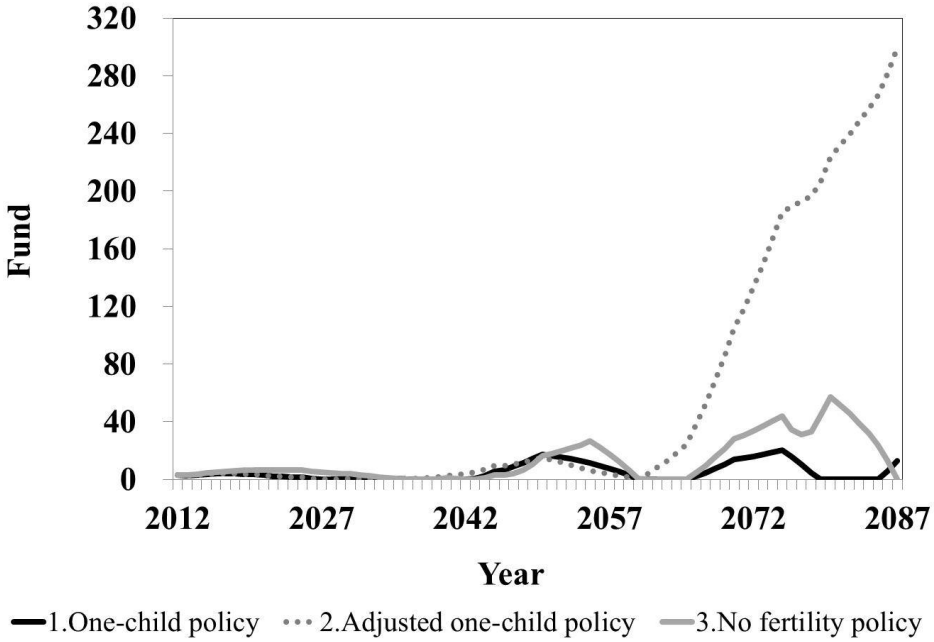
(b) Retirement age, $x_t^{(r)}$



(c) Indexation of pensions, λ_t



(d) Buffer fund, F_t



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Sensitivity Analysis

This subsection provides the sensitivity analysis for the value of the return of the buffer fund and the replacement rate (RR) respectively.

Different levels of return of the buffer fund. Chinese central government has approved the regulation to invest up to 30% of its pension fund into the domestic stock market on August 17th 2015. Previously pension fund was invested in the bank deposits and treasury bonds with a very low yield around 3%, which was lower than the inflation rate, i.e. pension fund is depreciating. This subsection analyses two levels

of return higher than the value of the baseline scenario, i.e. 3%. As shown in Table 5.1, even in the case of a rate of return of 8%, the contribution rate and retirement age would need to increase to values in the range of 22.62%-26.18% and 54.86-57.34 respectively, depending on the demographic scenarios, whereas the indexation of pensions would reach a value around 3% at the end of the period.

Table 5.1: ABM when the three variables are modified simultaneously under different values of the return of the buffer fund

	c_t	$x_t^{(r)}$	λ_t
S1(One-child policy), $J_t = 5\%$	26.20%	57.54	3.00%
S2(Adjusted one-child policy), $J_t = 5\%$	24.08%	56.49	3.02%
S3(No fertility policy), $J_t = 5\%$	24.08%	54.93	3.04%
S1(One-child policy), $J_t = 8\%$	26.18%	57.34	3.01%
S2(Adjusted one-child policy), $J_t = 8\%$	23.89%	56.38	3.03%
S3(No fertility policy), $J_t = 8\%$	22.62%	54.86	3.14%

Own source

Different levels of the replacement rate. This subsection analyses the optimal paths of the decision variables after the initial pension is set at 50% of the average salary instead of 61% as in our baseline scenario. As shown in Table 5.2, the decision variables also need to be adjusted in order to guarantee the sustainability of the system over the next 75 years.

Table 5.1 and Table 5.2 show that more optimistic assumptions regarding the levels of the buffer fund and replacement rate do not guarantee the long-term sustainability of

Table 5.2: ABM when three variables are modified simultaneously under different values of the RR.

	c_t	$x_t^{(r)}$	λ_t
S1(One-child policy), $RR = 50\%$	24.20%	56.56	3.17%
S2(Adjusted one-child policy), $RR = 50\%$	24.05%	54.51	3.33%
S3(No fertility policy), $RR = 50\%$	23.80%	54.17	3.42%

Own source

the Chinese pension system under any of the three demographic scenarios considered.

5.5 Summary

This chapter builds population projections in China under different fertility policies over the next 75 years and evaluates their implications for the long-term sustainability of the pension system. Even if the one-child policy had never been conducted, the old-age dependency ratio in 2087 would be 81.01%, i.e. one pensioner financed by 1.2 contributors. In the case of one-child policy implemented in 1979 and keeps in place until 2087, the old-age dependency ratio would be 124.94% at the end of the period analysed, i.e. there will be more pensioners than the contributors in the Chinese PAYG pension system.

Following Godínez-Olivares et al. (2016a), we propose a combination of different reforms (automatic balancing mechanism) involving the contribution rate, retirement age and indexation of pension that restores not only the sustainability but also the liquidity of the system. In order to restore the sustainability of the system, in the case of only

one decision variable is modified, the contribution rate and the effective retirement age would need to increase to values in the range of 42.53%-59.36% and 63.72-67.89 respectively, whereas the indexation of pension would need to decrease to value in the range of -3% to 0%. If the three decision variables are modified simultaneously, the contribution rate and the effective retirement age would need to increase to values in the range of 23.20%-26.64% and 55.45-57.54 respectively, whereas the indexation of pension would need to decrease to value in the range of 3%-3.7%, depending on the different fertility policies.

This chapter shows that the sustainability of the Chinese pension system is not guaranteed under any of the different demographic scenarios analysed, and the one-child policy is harmful to the long-term sustainability of the Chinese pension system.

Future research is focused on analysing the impact of rural to urban migration on the demographic structures, since the net migration rates provided by United Nations (2015) only takes into account the international migration. With this aim in mind, we adjusting the net migration rates from United Nations (2015) by a rural to urban migration rate, and calculate the optimal paths of the contribution rate, retirement age and indexation of pension based on the ABM for China. As Dyson (2011) has stated that the deep reason behind urbanization process is the demographic transition, and the continuous rural to urban migration will influence the demographic structure in the urban area. Thus, analysis of the rural to urban migration also shows the implications of urbanization process on the sustainability of the Chinese PAYG pension system in urban areas.

Chapter 6

Implications of Urbanization Process

The urbanization rate in China has expanded from 12% to 50% in 6 decades between 1950 and 2011, while the same transition took 150 years to occur in Europe and 210 years in Latin America and the Caribbean. The key reason behind the fast urbanization in China is the change of demographic structures due to the rural to urban migration. The demographic change will have an enormous impact on the PAYG pension system which operates in the way that current contributors pays pensions to current pensioners. This chapter analyses the impact of urbanization on the long-term sustainability of the Chinese PAYG pension system. The result shows that contrary to the current public hypothesis that huge inflow of the working-age population will restore the demographic balance between contributors and pensioners, the rapid urbanization process will result in a higher old-age dependency ratio after 2050. Overall, by analysing the sustainability of Chinese pension system over the next 75 years, the result shows that urbanization

leads to a less sustainable pension system in China.

6.1 Introduction

An urbanization process is a shift of part of a population from rural settlements, where agriculture is the dominant economic activity, to urban settlements, characterized by industrial and service activities (Montgomery et al., 2004). Urbanization is a global trend. According to United Nations (2014), over half of the world's population (54%) is currently living in urban areas, while the urbanization rate[45] was only 30% in 1950. United Nations (2014) projects the urbanization rate to be 66% by 2050. The global trend of urbanization is linked to sustainable development. In terms of advantages, a greater concentration of people in urban areas can facilitate economic and social development because, as noted by Grübler and Fisk (2013), nearly 80% of the global gross domestic product (GDP) is generated in cities. Urbanization also improves the living standards for society as a whole, and Cohen (2006) has found that governments can take advantage of the economies of scale that cities provide to supply an infrastructure (such as roads and electricity) and basic services (such as education and healthcare) to a large population at a much lower cost than would be required to reach the same number of people dispersed in rural areas. However, rapid and unplanned urban growth also has disadvantages. Urban inequalities emerge with the growth of urbanization (Fink et al., 2014), and the urban poor face greater exposure to pollution and health risks

[45]The urbanization rate is defined as the number of the population living in the urban area divided by the total population, and is expressed as a percentage (United Nations, 2014).

(Balk et al., 2009). Furthermore, unplanned urban expansion leads to environmental degradation, because land areas now occupy green areas. Angel et al. (2011b) stated that today's cities are growing twice as fast in terms of land area as they are in terms of population. Furthermore, Angel et al. (2011a) and Seto et al. (2012) have forecasted that the global urban land area will triple in size by 2030. To respond to these challenges and opportunities, the Rio+20 United Nations Conference on Sustainable Development highlighted the need for sustainable cities as a matter of great urgency in the United Nations development agenda. At the same time, the 3rd United Nations Conference on Housing and Sustainable Urban Development (Habitat III) will bring world leaders together to improve sustainability in an urbanizing world.

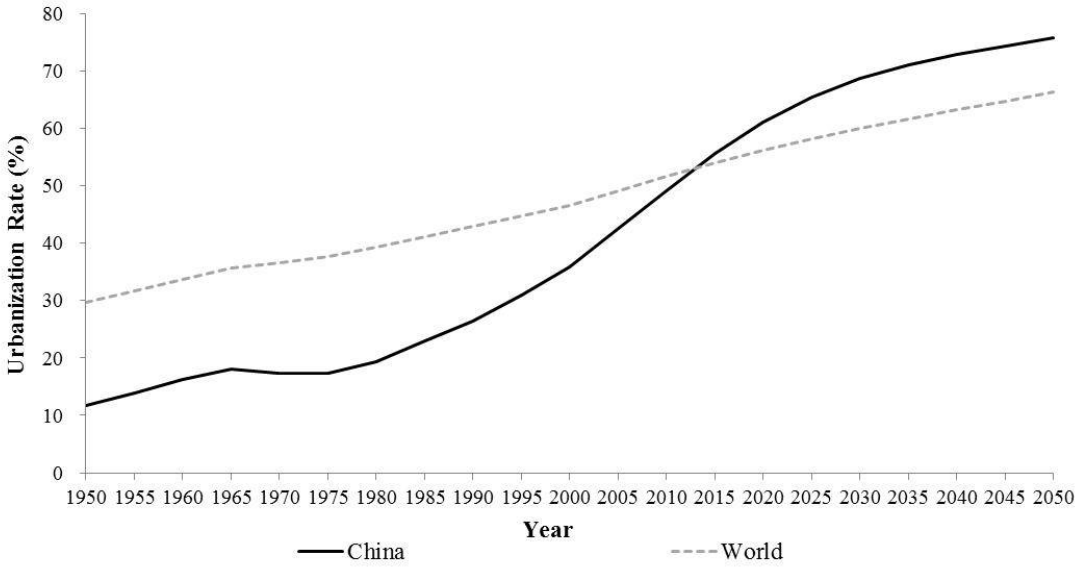
China, as the country with the largest population in the world, is projected to have the largest decline in the rural population by 2050, according to United Nations (2014). The speed of urbanization in China is much faster than the world average level, with the urbanization rate having grown from 12% in 1950 to 56% in 2015, and is projected to be 76% by 2050 (United Nations, 2014) (See Figure 6.1 for the urbanization rate for China and World). In 2011, China's urbanization rate surpassed 50%, which meant this was the first time in China's long history that more citizens were living in cities than in rural areas. The urbanization process in China has drawn much attention, both because of its speed and scale. It took 6 decades for the urbanization rate in China to expand from 10% to 50%, while the same transition took 150 years to occur in Europe and 210 years in Latin America and the Caribbean. In 2011, the number of internal migrants reached 260 million in China, with a further 310 million people

expected to migrate from rural to urban areas during the next two decades (Pan et al., 2013). Such rapid urbanization in terms of speed and scale is unprecedented in human history. Since 1995, rural migrants have become the main source of urban population expansion, comprising 31.2% of urban residents in 2010. The demographic profile of internal migrants will have an enormous impact on demands for employment and social services in China (Cai and Wang, 2012).

Dyson (2011) has claimed that the fundamental reason behind the urbanization process is the demographic transition, and that the continuous rural to urban migration will influence the demographic structure in the urban area. Furthermore, the demographic change will have a major impact on the sustainability of a PAYG pension system, in which current active workers pay the benefits for current pensioners. This chapter aims to fill a gap in the literature by investigating the consequences of the urbanization process for the PAYG pension system in terms of long-term sustainability. With this aim in mind, we analyse how rural to urban migration will influence the urban PAYG pension system in China.

Following this introduction, in Section 6.2, we define and generate a rural to urban migration rate, and incorporate it into the cohort component method by adjusting the net migration rates in the population projections. In Section 6.3, we calculate the optimal paths for the contribution rate, retirement age, and indexation of pensions in the Chinese pension system by considering the impact of the urbanization process. Finally, Section 6.4 provides a summary.

Figure 6.1: Urbanization rate for China and World, 1950-2050



Own source based on United Nations (2014)

6.2 Population Projections for Urbanization Process

In this section, we use the cohort component method described in Section 5.3.1 to calculate the population pyramids in China by adding the rural to urban migrants into the net migrants. The results with the rural to urban migration will be compared with the baseline scenario (Scenario 2 in Chapter 5, which is the scenario showing the current situation in China) in order to see the implications of the urbanization process.

6.2.1 Rural to Urban Migration Rate

The rural to urban migration rate is defined as the increasing rate of the urbanization rate. The formula to calculate the rural to urban migration rate, $m_r(t)$, is as follows:

$$m_r(t) = \frac{U(t) - U(t-1)}{U(t-1)} \tag{6.1}$$

where $U(t)$ is the urbanization rate at year t. The rural to urban migration rate measures the proportion of the rural to urban migrants accounts for the total number of the urban population at year t.

6.2.2 Main Data and Scenario Analysed

- Baseline scenario: Scenario 2 in Chapter 5 (which is the scenario showing the current situation in China with fertility rate equal to 2[46]) is provided as the baseline scenario in order for the comparison with the migration scenario.

- Migration scenario: The survival rates and fertility rates under the migration scenario are the same as the baseline scenario, while the net migration rates[47] are adjusted by the rural to urban migration rates during the calculation of the population projections in the urban area.

- The urbanization rates, $U(t)$, which are used to generate the rural to urban migration rates, is from United Nations (2014). Since United Nations (2014) only

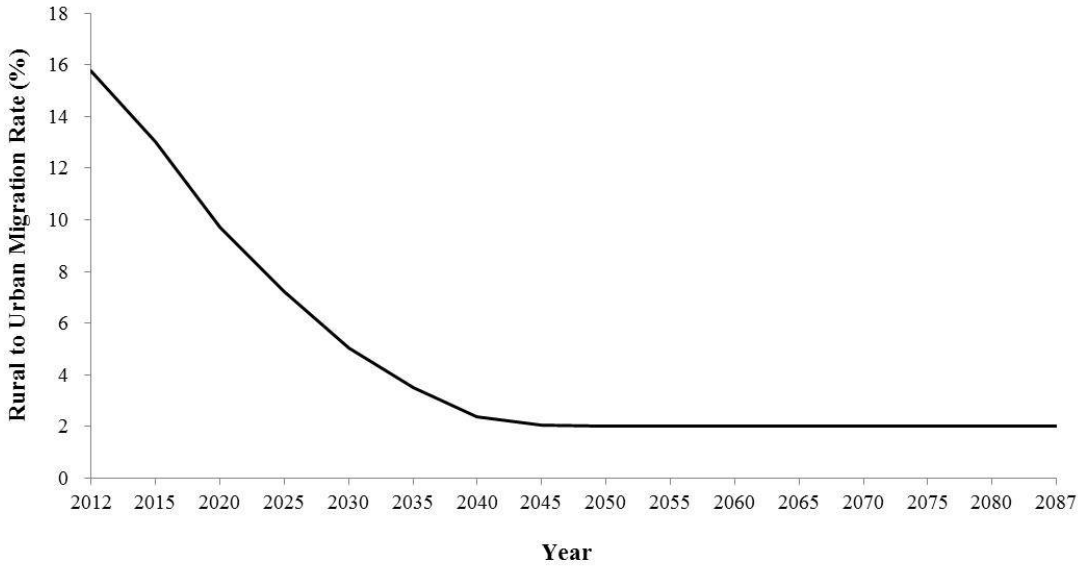
[46] According to the latest regulation in China (The 13th Five-Year Plan for Economic and Social Development of the People ł Republic of China, i.e. the 13th Five-Year Plan) now every family can have two children.

[47] The net migration rates from United Nations (2015) have not taken into account the rural to urban migration.

provides the urbanization rates until 2050, it is assumed that the rural to urban migration rates, $m_r(t)$, remain constant from 2050 to 2087[48]. Figure 6.2 shows the rural to urban migration rates of China over the period 2012-2087.

- The age distribution of the rural to urban migrants are from the 6th population census (Department of Population and Employment Statistics, National Bureau of Statistics of China, 2010).

Figure 6.2: Rural to urban migration rate for China, 2012-2087



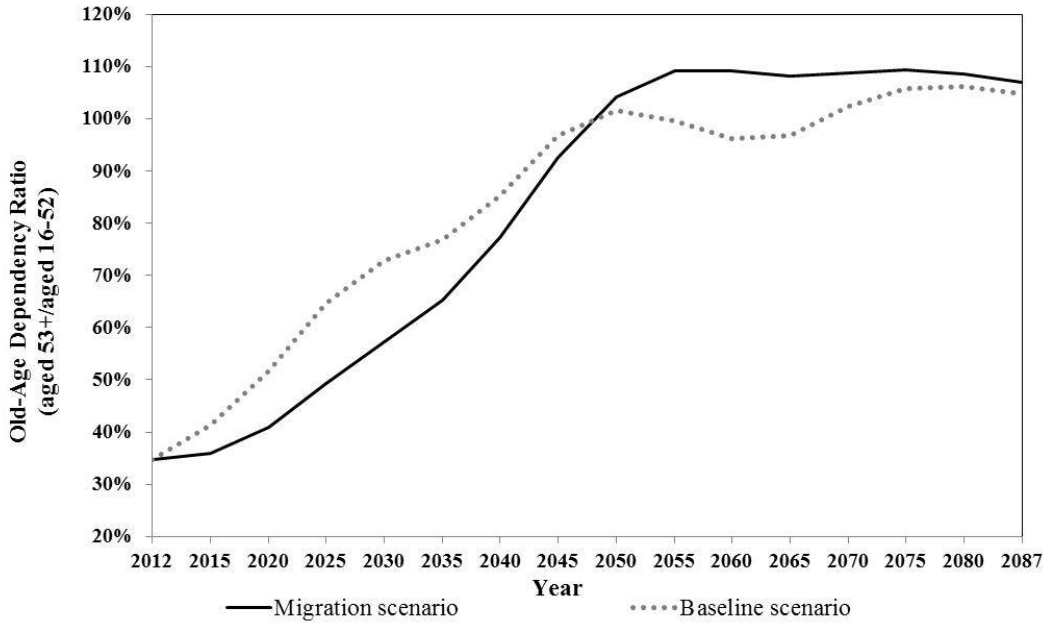
Own source

[48]The urbanization rate will be 88.94% in 2087, if the rural to urban migration rates keep constant from 2050 to 2087.

6.2.3 Results

From Figure 6.3, we can see, the old-age dependency ratios under migration scenario are lower than the baseline scenario from 2012 to 2050. It is because the rural to urban migrants are young of age, the average age of the migrants are 34.75 according to the 6th population census (Department of Population and Employment Statistics, National Bureau of Statistics of China, 2010). The huge inflow of the working-age population leads to a low dependency ratio at the beginning. However, as the urbanization rates approach 100%, the number of rural to urban migrants will decrease in the future. At the same time, the early huge inflow of the migrants is starting to retire. It therefore results in a higher old-age dependency ratio after 2050. Figure 6.4 shows the population pyramids in urban areas under the migration scenario and the baseline scenario in 2012, 2050 and 2087. We can see the number of old-age population is increasing more rapidly under migration scenario, compared to the baseline scenario.

Figure 6.3: Old-age dependency ratios (aged 53+/aged 16-52) for urbanization process, 2012-2087

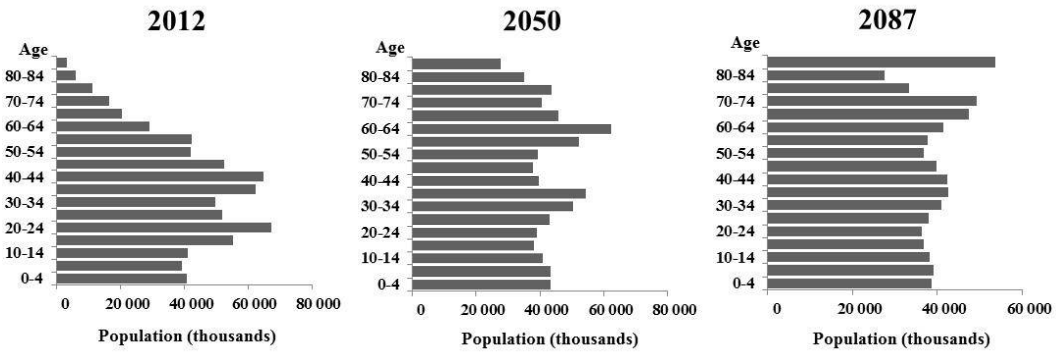


Own source

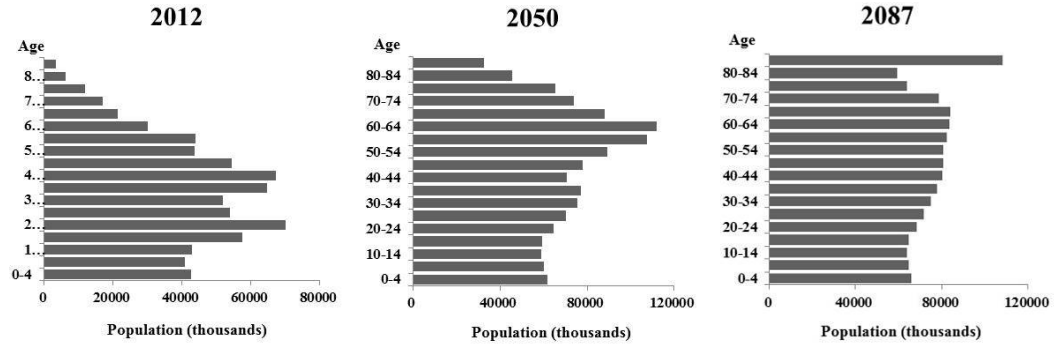
Note: Male to female sex ratio of rural to urban migrants has been taken into account, the ratio is 2.30 male per female according to 6th population census in China.

Figure 6.4: Evolution of population pyramids in urban areas under migration and baseline scenarios

(a) Baseline scenario



(b) Migration scenario



Own source

6.3 ABM to Restore the Sustainability

This section provides the results of ABM under migration scenario and baseline scenario following the methodology in Section 5.4. First, the results with only one decision variable modified are provided. Second, the results with three decision variables modified simultaneously are shown. We also carried out a sensitivity analysis for the

different values of rural to urban migration rates from 2050 to 2087.

6.3.1 Mechanism

The methodology used here is the same as in Section 5.4.1. That is, the mechanism identifies the optimal paths of the three key decision variables (contribution rate, c_t , retirement age, $x_t^{(r)}$, and indexation of pensions, λ_t) while minimizing the net present value of the buffer fund, F_t , subject to some constraints.

The buffer fund is calculated as:

$$F_t = (1 + J_t)F_{t-1} + c_t W_t(g_t, x_t^{(r)}) - E_t(g_t, x_t^{(r)}, \lambda_t) \tag{6.2}$$

The liquidity constraint is set as $F_t \geq 0$, for all t, i.e. no deficit is allowed in the Chinese pension system.

The ABM is defined as the following optimization problem:

$$
\begin{aligned}
& min_{c_t, x_t^{(r)}, \lambda_t} \sum_{t=0}^{T} \frac{F_t(c_t, g_t, x_t^{(r)}, \lambda_t, J_t)}{(1+\delta)^t} \\
& s.t. = \begin{cases}
c_{min} \leq c_t \leq c_{max}; \\
x_{min}^{(r)} \leq x_t^{(r)} \leq x_{max}^{(r)}; \\
\lambda_{min} \leq \lambda_t \leq \lambda_{max}; \\
c_{1\triangle} \leq \frac{c_{t+1}}{c_t} \leq c_{2\triangle}; \\
x_{1\triangle}^{(r)} \leq \frac{x_{t+1}^{(r)}}{x_t^{(r)}} \leq x_{2\triangle}^{(r)}; \\
\lambda_{1\triangle} \leq \frac{\lambda_{t+1}}{\lambda_t} \leq \lambda_{2\triangle}; \\
F_t \geq 0.
\end{cases}
\end{aligned}
\tag{6.3}
$$

6.3.2 Data and Assumptions

The data and assumptions under migration scenario are the same as the baseline scenario (Scenario 2 in Chapter 5) in order for the easy comparison between the two scenarios.

- Data on the number of participants in the Chinese contributory PAYG pension system in urban areas is obtained from Human Resources and Social Security Statistics Bulletin 2012.

- Data on the average salary in 2012 is equal to 47,593 RMB/year. The infor-

mation on wage distribution by age group is taken from the Ministry of Human Resources and Social Security of the People's Republic of China. Annual real wage growth rate, g_t , is equal to 7.62%. The initial contribution rate, c_t, is 20%.

- The average monthly pension is equal to 1,721 RMB/month (20,652 RMB/year). The initial pension is equal to 61% of the average salary in the Chinese PAYG pension system, i.e. the replacement rate is equal to 61%. The initial revaluation of pension in payments, λ_t , is equal to 9.13%. The initial effective retirement age in China is 53.

- Data on the initial amount of buffer fund is from National Social Security Fund Report 2012. The growth rate of the pension fund, J_t, is assumed to be 3%. The discount rate, δ, is also equal to 3%.

- The lower bounds of the contribution rate, retirement age, and indexation of pensions are equal to 20%, 53, and -10% respectively, whereas the upper bounds are set respectively as 65%, 70, and 10%, in the case of only one decision variables is modified. While three variables are modified simultaneously, the lower bounds are given by 20%, 53, and 0% respectively, and upper bounds are 30%, 60, and 10% respectively.

- The maximum increase for contribution rate and retirement age in each year is assumed to be 2.5% and 6 months, whereas the minimum decrease for pension in payment is set to be -1%, in the case of only one decision variable is modified.

The constraints are assumed to be 2.5%, 3 months and -0.5% respectively when three variables are modified simultaneously.

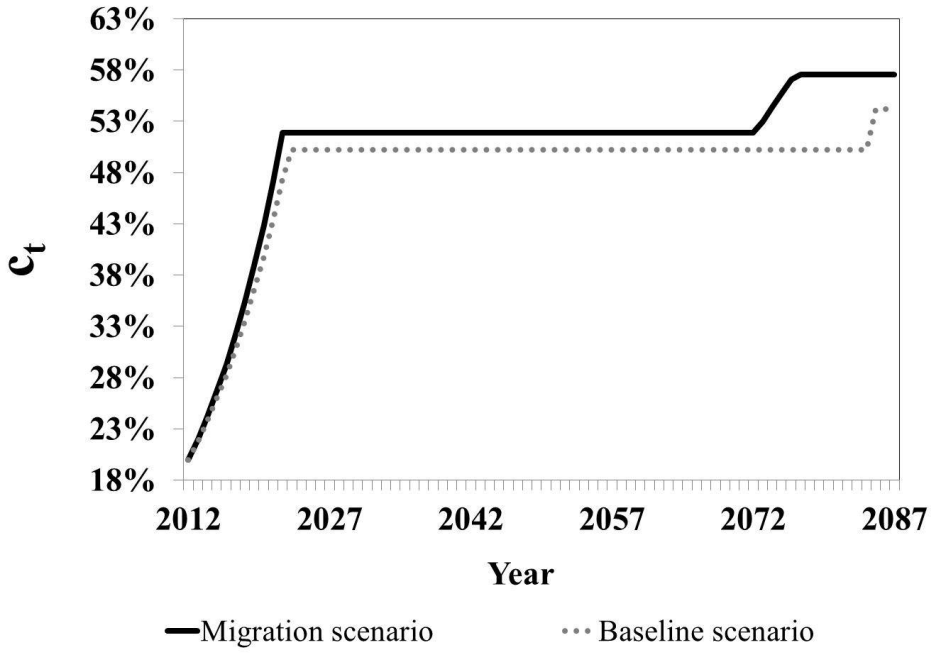
6.3.3 Results

ABM with Only One Modified Decision Variable

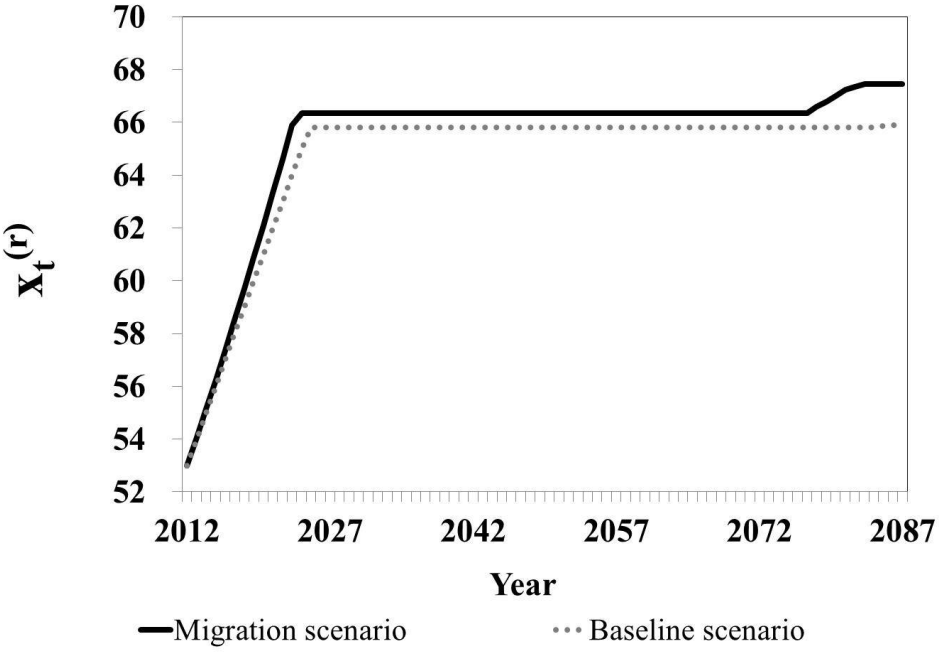
Figure 6.5a shows that when the contribution rate is the only decision variable, it would need to increase to 57.56% in 2087 under migration scenario, which is 3.01% higher than the baseline scenario. The retirement age needs to increase to 67.44 as shown in Figure 6.5b, whereas its value would stable at 65.95 under the baseline scenario. If the indexation of pensions is the only decision variable, as shown in Figure 6.5c, its value would need to decrease at an annual rate of 2.22% under migration scenario, whereas its value needs to decrease at 1.8% annually under the baseline scenario.

Figure 6.5: ABM for urbanization process when one variable is modified, 2012-2087

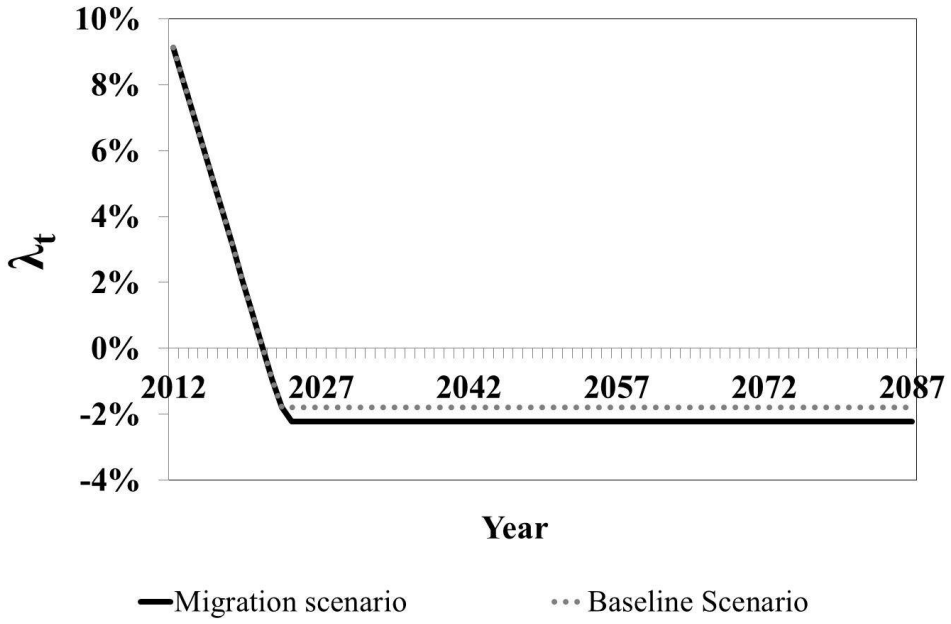
(a) Contribution Rate, c_t



(b) Retirement age, $x_t^{(r)}$



(c) Indexation of Pensions, λ_t



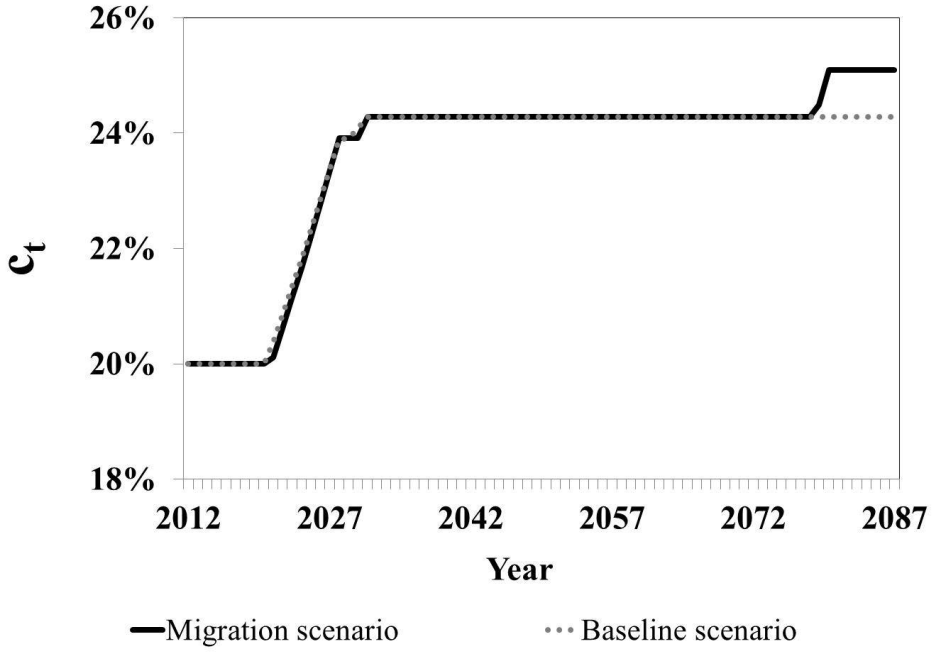
ABM with Three Decision Variables Modified Simultaneously

As shown in Figure 6.6, in the case of migration scenario, the contribution rate and retirement age would need to increase to 25.10% and 57.4 respectively, while the indexation of pensions needs to decrease to 3.05%. Whereas the values of the contribution rate, retirement age and indexation of pension are 24.28%, 57.17 and 3.17% respectively under the baseline scenario. Figure 6.6d shows that liquidity constraints are imposed in our minimization problem, since the system need to have enough money to cover the expenditure on pensions on an annual basis.

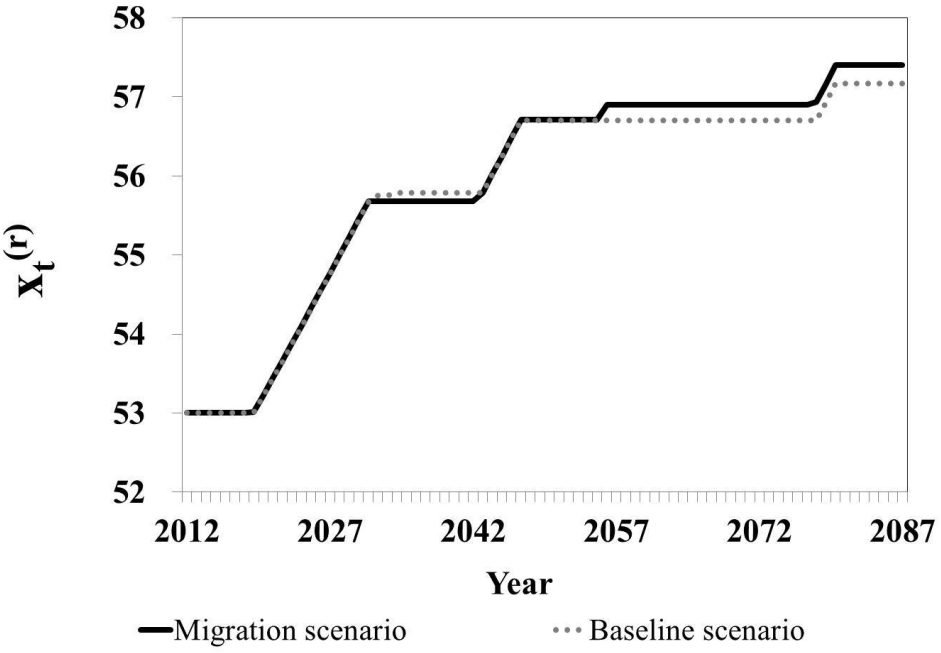
From Figure 6.5 and Figure 6.6, we can see, the urbanization process worsens the long-term sustainability of the Chinese PAYG pension system.

Figure 6.6: ABM for urbanization process when three decision variables are modified simultaneously, 2012-2087

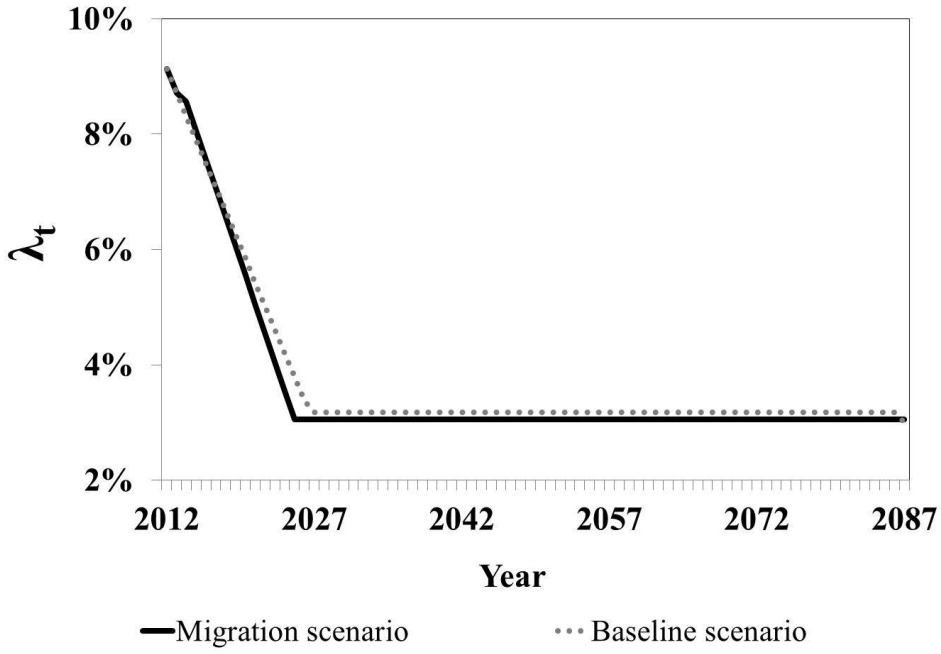
(a) Contribution Rate, c_t



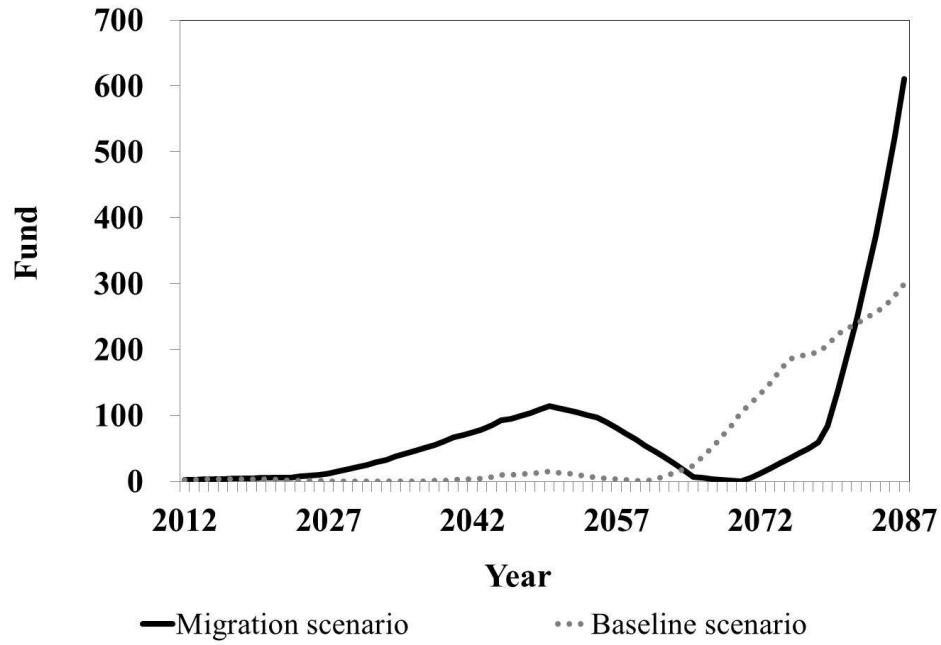
(b) Retirement age, $x_t^{(r)}$



(c) Indexation of Pensions, λ_t



(d) Buffer Fund, F_t



Sensitivity Analysis

This subsection provides a sensitivity analysis for the different values of the rural to urban migration rate from 2050 to 2087. Table 6.1 shows that the value of the contribution rate and retirement age under migration scenario is in the range of 24.79%-26.14% and 57.34-57.52 respectively, which is always higher than the baseline scenario with the value of 24.28% and 57.17 respectively. Whereas the indexation of pensions is in the range of 3.02%-3.10%, which always lower than the baseline scenario with the value of 3.17%. As a result, the values under all the migration scenarios are worse than the baseline scenario. It means urbanization process worsens the sustainability of the Chinese pension system, regardless of the assumptions for the different values of the rural to urban migration rates.

Table 6.1: ABM when the three variables are modified simultaneously under different values of the rural to urban migration rate from 2050 to 2087

	c_t	x_t	λ_t
Baseline Scenario	24.28%	57.17	3.17%
Migration Scenario, $m_r(t) = 0\%$	26.14%	57.52	3.02%
Migration Scenario, $m_r(t) = 1\%$	26.02%	57.41	3.03%
Migration Scenario, $m_r(t) = 3\%$	24.79%	57.34	3.10%

Own source

Note: When $m_r(t)$ is greater than 3%, the urbanization rate will exceed 100% in 2087.

6.4 Summary

This chapter analyses the implications of the urbanization process on the long-term sustainability of the pension system by introducing a rural to urban migration rate and applying it to the cohort component method. The result of the population projections shows that the old-age dependency ratio under migration scenario is lower than the baseline scenario at the beginning of the period from 2012 to 2049, but becomes higher than the baseline scenario from 2050 to 2087.

In order to restore the sustainability of the Chinese pension system, in the case of only one decision variable is modified, the contribution rate and the effective retirement age would need to increase by 3.01% and 18 months respectively, whereas the indexation of pensions needs to decrease by 0.42% under migration scenario, compared to the baseline scenario. If three decision variables are modified simultaneously, the contribution rate and the effective retirement age would need to increase by 0.82% and 3 months respectively, whereas the indexation of pensions would need to decrease by 0.12% under migration scenario, compared to the baseline scenario.

This chapter shows that the demographic change due to the rural to urban migration will have an enormous impact on the Chinese PAYG pension system in the urban area. Contrary to the current public hypothesis that the huge inflow of the working-age population will restore the demographic balance between the contributors and pensioners, the rapid urbanization process will result in a demographic structure with more pen-

sioners than contributors at the end of the period analysed, and at the same time lead to a higher old-age dependency ratio after 2050. Thus, the urbanization process is not helpful to solve the ageing problem in China. As a result, the urbanization process worsens the long-term sustainability of the Chinese pension system.

Chapter 7

Conclusions

This study analysed the long-term sustainability of the Chinese PAYG pension system in urban areas, as well as the factors influencing the sustainability of the pension system in China.

This work was motivated by the decline in fertility rates and the increase in longevity in China, which has resulted in a serious ageing problem. At the same time, the recent demographic change has led to an enormous increase in the old-age dependency ratio. Since the PAYG pension system requires a balance between the benefits paid to pensioners and the contribution made by active works, the financial health of the Chinese PAYG pension system and the method to restore the financial equilibrium to this pension system have become hot topics in academic literature. However, current literature lacks analysis on the long-term sustainability of the pension system. Studies

that analyse the current political and social situation in China, including the one-child policy and the urbanization process, are also restricted in the area of economic growth. This study fills this gap.

Chapter 2 explains some basic concepts in a pension system at first, and then give examples for the pension systems around the world. The vast majority of the countries around the world chose the PAYG scheme at the beginning of their public pension systems and keeps this form till now. Since PAYG system could finance the pension payments immediately after the establishment of the system. The design and reforms of the pension system should follow two objectives – adequacy and sustainability. Furthermore, the current context of rapid global ageing has led to serous concerns of the financial sustainability in the PAYG pension system. A lot of countries has already taken the pension reforms with the objective to achieve an sustainable pension system at the same delivering the adequacy among the participants.

After that, Chapter 3 focuses on the pension systems in China. It reviews the evolution of the entire public pension system in China based on three time periods. The first period is from 1951 to 1986, when the preliminary system has been established after the foundation of the People's Republic of China. The system only exited within each enterprise in urban areas. The second period is from 1986 to 1997, the individual accounts has been introduced during this period in order to increase the labour mobility in the competition between SOEs and private enterprises in 1980s. The final stage is from 1997 till now, when the current standardized system has been gradually developed. Current Chinese pension system faces a lot of challenges. The rapid ageing and

urbanization together with the expansion of higher education and loss of trust among participants have raise serious concerns in the pension system. To solve these problems, pension reforms are needed urgently. Discussions of future directions of pension reforms in this chapter cover not only the financial sustainabilities but also the pension adequacy in China.

Chapter 4 analyses the Chinese PAYG pension system in urban areas for the period 2007-2012 using two actuarial balance methodologies. The first methodology is the Swedish solvency ratio, based on verifiable facts. The second methodology is the United States' actuarial balance indicator, which takes into account projected demographic and economic structures over the next 75 years. This is the first estimate of sustainability level of the Chinese PAYG pension system. Both methodologies show that the Chinese pension system, in its current form, is unsustainable. The results show that the values of liabilities are more than double that of assets in the case of Swedish methodology. Furthermore, the contribution rate would need to increase by 39.09% immediately to obtain a sustainable Chinese PAYG pension system for the next 75 years, based on the United States' methodology. Some advice on the parametric reforms to restore the financial health of the system is also provided in this chapter.

Since the results in Chapter 4 show the unsustainability of the current Chinese PAYG pension system, it is interesting to analyse the factors that influence the financial equilibrium in China. Chapter 5 analyses the implications of the one-child policy on the long-term sustainability of the Chinese PAYG pension system. In 1979, the Chinese government introduced the one-child policy with the aim of controlling the country's

rapid population growth. This policy will lead to deficits in the Chinese PAYG pension system since the country's individuals are living longer and having fewer children. Three demographic structures for different fertility policies ('One-child policy is implemented as in 1979', 'One-child policy is relaxed as in 2013', and 'No fertility policy implemented since 1979') are calculated using the cohort component method. The ABM to restore the sustainability of the pension system over the next 75 years is provided for each demographic structure.

The main finding in Chapter 5 is that, the one-child policy is harmful to the sustainability, and all the scenarios studied indicate an urgent need to introduce mechanisms to guarantee the long-term sustainability of the Chinese pension system. In order to restore the sustainability of the system, if the three decision variables are modified simultaneously, the contribution rate and the effective retirement age would need to increase to 23.20%-26.64% and 55.45-57.54, respectively, whereas the indexation of pensions would need to decrease to 3%-3.7%, depending on the different fertility policies.

Chapter 6 analyses the implications of urbanization process on the long-term sustainability of the Chinese PAYG pension system. The urbanization rate in China has expanded from 12% to 50% in 6 decades between 1950 and 2011, while the same transition took 150 years to occur in Europe and 210 years in Latin America and the Caribbean. The key reason behind the fast urbanization in China is the change of demographic structure due to the rural to urban migration. The huge inflow of the rural to urban migrants will have an impact on the PAYG pension system which operates

in the way that current contributors pays pensions to current pensioners. This chapter analyses the impact of urbanization on the long-term sustainability of Chinese PAYG pension system by adjusting the net migration rates using the rural to urban migration rates.

The results in Chapter 6 show that demographic changes due to rural to urban migration will have an enormous impact on the PAYG pension system. Contrary to the current public hypothesis that a huge inflow of the working-age population will restore the demographic balance between contributors and pensioners, the rapid urbanization process will result in a higher old-age dependency ratio after 2050. In order to restore the sustainability of the Chinese PAYG pension system over the next 75 years, the effect of urbanization process would increase the contribution rate and the effective retirement age by 0.82% and 3 months respectively, as well as decrease the indexation of pensions by 0.12%, as compared with the scenario without rural to urban migration. As a result, the urbanization process will worsen the long-term sustainability of the Chinese PAYG pension system.

Overall, the Chinese PAYG pension system is unsustainable in its current form, at the same time, the one-child policy and the urbanization process make the sustainability of the pension system even worse. The mechanisms to restore the financial equilibrium of the system should be undertaken immediately in order to guarantee the long-term sustainability of this pension system.

There are also limitations with the study of this thesis. Data on the contributors and

pensioners per age is currently not available in China, due to the lack of data collection system. This study has solved this problem, by assuming the age distribution of contributors as the distribution of urban employed workers, and the age distribution of pensioners as the distribution of urban elder people. However, the study could be improved by having the direct access to the age distribution of contributors and pensioners. Since this is a common problem in the research of the Chinese pension system, the Chinese government has realised it and tried to solve it by setting up a standardised electronic management system, such as 'Golden Insurance Project', to collect the pension data in the country's level recently.

Future research could focus on two directions:

1. To analyse the other political or social events in China, which affect the long-term sustainability of the Chinese PAYG pension system.

2. To analyse the factors that influence the individuals' retirement behaviours.

To give an example, the analysis on the first direction could focus on the impact of recent central government's approval, which allowed the pension fund to be invested in the stock market.

Chinese central government has approved the regulation to invest up to 30% of its pension fund into the domestic stock market on August 17th 2015, due to the growing ageing problem and recently biggest crash in the stock market. Previously pension

fund was invested in the bank deposits and treasury bonds with a very low yield around 3%, which was lower than the inflation rate, i.e. pension fund is depreciating. This regulation has raised serious concerns for the Chinese pension system, since the pension fund now is facing a lot of higher risks than before.

After the new regulation, Chinese pension fund can be invested into two general categories. One is lower risk assets, such as bank deposits, treasury bonds and so on, the interest rates of which are similar with the bank deposit rate. The other kind of investment is higher risk assets, such as domestic stocks, stock indexes, the proportion of this kind of investment cannot exceed 30% of the total assets.

By analysing the different scenarios for the return of the buffer fund based on the ABM to restore the sustainability of the Chinese pension system over the next 75 years, we can compare the differences in the optimal paths of the three key decision variables (the contribution rate, retirement age and indexation of pensions). It thus will provide us with a clear view of the consequences of this regulation on the long-term sustainability of the Chinese pension system.

The motivation of the study on the second direction is that, the world main trend of pension system reforms is transferring from DB to DC. As stated in Oksanen (2010), Dorfman et al. (2013), and Zheng (2014), China is also considering transferring its pension scheme to NDC. This transformation shifts a lot of pressure for financial decisions about financing retirement from governments to individuals. Therefore, whether individuals can make the right retirement decision will directly influence the sustainability

of a pension system. At the same time, researchers have started to study the causal effects of financial literacy on individuals' retirement decisions. Lusardi and Mitchell (2009, 2011) stated that, those with more advanced financial knowledge are those more likely to be retirement-ready, and financial literacy is critical to retirement security around the world. However, there is no literature has directly review the causal effects of financial literacy and retirement decision in China. This study is going to analyse whether financial literacy influences individuals' retirement decisions in China, and also evaluate its impact. Instead of asking 'whether the individual has ever planned for his/her retirement' in a questionnaire as the previous literature, I'm going to use individuals' real retirement decisions at different time periods as a dummy variable in a regression model.

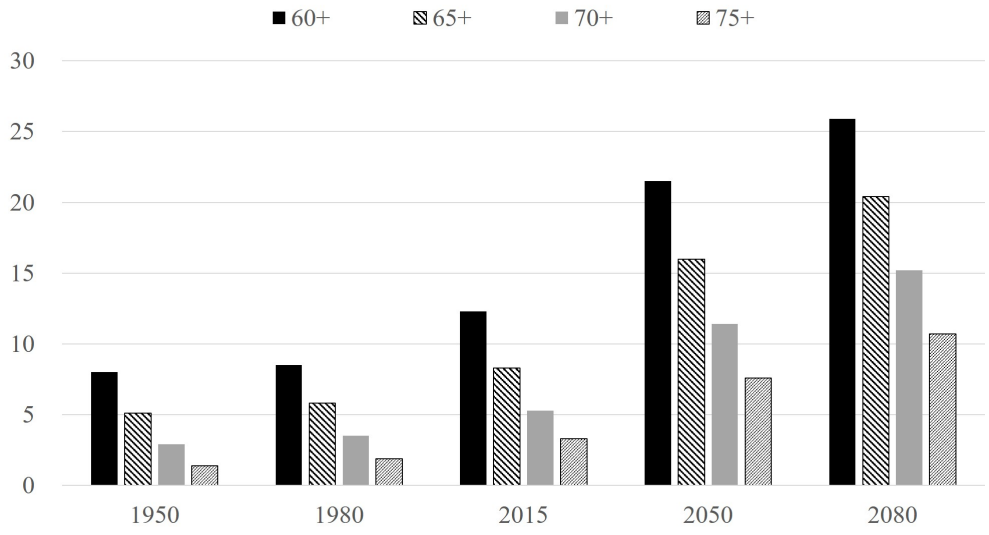
Though the focus of this study remains on China, it is expected that the findings are relevant for other countries who are also intended to change the pension system from DB to DC, and in which individual choices may influence retirement arrangements. This study can be interesting for the policy makers in the issues of whether education of financial literacy should be improved in China to make individuals' to be better prepared for their retirement.

Appendices

Appendix A

Share of Elderly People in the World

Figure A.1: Share of elderly people in the percentage of total population in the world (%).



Own source based on United Nations (2015)

The share of elderly people in the percentage of total population in the world has been growing rapidly. Figure A.1 shows the proportion of elderly people aged above 60, 65, 70, and 75 respectively. We can see that, the share of people aged above 60 has increased from 8% in 1950 to 12.3% in 2015, and it is going to be 25.9% by 2080. At the same time, the share of people aged 75 and above has grown from 1.4% in 1950 to 3.3% in 2015, and is projected to reach 10.7% in 2080.

Appendix B

Public Expenditure on Pensions around the World

Table B.1 shows that 22 out of 35 OECD countries will face increases in their public expenditure on pensions in future, based on the projections from OECD (2015). The overall pension expenditures around the OECD countries will grow up from current 9% of the total GDP to 10.1% in 2050. The expenditures will increase in vast majority of the major economies in the world. In China, it will increase from current 3.4% of the GDP to 9.2% in 2050.

Table B.1: Public expenditure on pensions in percentage of GDP (%), 2010-2050

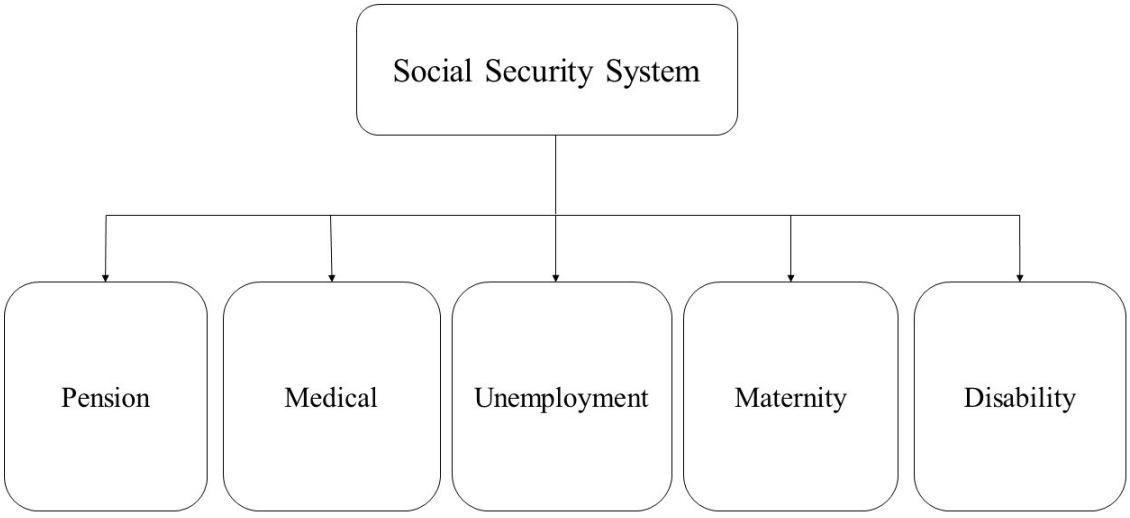
	2010-2015	2020	2025	2030	2035	2040	2045	2050	Change
OECD members									
Australia	2.9		2.5		2.5		2.6	2.6	-0.3
Austria	13.9	13.9	14.1	14.4	14.7	14.7	14.7	14.6	0.7
Belgium	11.8	12.7	13.8	14.7	15.2	15.2	15.1	15.0	3.2
Canada	4.9							6.3	1.4
Chile	5.5							3.8	-1.7
Czech Republic	9.0	9.0	9.1	9.0	8.8	9.0	9.3	9.6	0.6
Denmark	10.3	8.7	8.4	8.3	8.2	8.0	7.7	7.5	-2.8
Estonia	7.6	7.6	7.3	7.1	7.0	6.9	6.8	6.7	-0.9
Finland	12.9	14.2	14.9	15.0	14.4	13.6	13.0	12.8	-0.1
France	14.9	14.6	14.9	14.7	14.2	13.8	13.3	12.8	-2.1
Germany	10.0	10.3	10.9	11.6	12.1	12.2	12.3	12.5	2.5
Greece	16.2	15.5	15.0	14.4	14.1	14.1	14.1	14.4	-1.8
Hungary	11.5	9.8	9.3	8.9	9.1	9.6	10.4	10.7	-0.9
Iceland	3.3							3.5	0.2
Ireland	7.4	8.0	8.7	9.1	9.6	10.0	10.2	10.0	2.6
Israel									0.0
Italy	15.7	15.3	15.5	15.7	15.8	15.8	15.5	14.8	-0.9
Japan	11.2	10.5	9.9						-11.2
Korea	1.7							12.5	10.8
Luxembourg	9.4	10.6	11.2	11.9	12.4	12.7	12.7	12.5	3.1
Mexico	1.5							1.3	-0.2
Netherlands	6.9	7.1	7.4	7.7	8.1	8.3	8.3	8.1	1.2
New Zealand	5.5							7.3	1.8
Norway	9.9	10.7	11.1	11.3	11.4	11.4	11.4	11.6	1.7
Poland	11.3	10.6	10.5	10.4	10.1	10.0	10.1	10.4	-0.9
Portugal	13.8	14.6	14.9	15.0	15.0	14.8	14.6	14.4	0.6
Slovak Republic	8.1	8.0	7.9	7.6	7.7	8.1	8.6	9.1	1.0
Slovenia	11.8	11.1	11.4	12.3	13.3	14.3	15.1	15.6	3.8
Spain	11.8	11.8	11.4	11.2	11.5	11.9	12.5	12.3	0.5
Sweden	8.9	8.3	8.1	7.9	7.8	7.5	7.3	7.2	-1.7
Switzerland	9.6							10.7	1.1
Turkey	6.3							17.0	10.7
United Kingdom	7.7	7.4	7.8	7.9	8.2	8.4	8.1	8.1	0.5
United States	4.9							6.1	1.2
OECD	9.0							10.1	1.1
Other major economies									
Argentina	7.4							11.9	4.5
Brazil	9.1							16.8	7.7
China	3.4							9.2	5.8
India	1.0							0.7	-0.3
Indonesia	0.7							1.6	0.9
Russian Federation	8.1							14.9	6.8
Saudi Arabia	2.2							8.1	5.9
South Africa	1.9							3.5	1.6
EU28	11.3	11.2	11.4	11.6	11.7	11.7	11.6	11.4	0.1

Own source based on OECD (2015)

Appendix C

Social Security System in China

Figure C.1: Structure of social security system in China



Own source

The entire social security system in China consists of five parts, which are pension system, medical insurance system, unemployment insurance system, maternity insurance

system and disability insurance system, as shown in Figure C.1.

Pension system in China, or also known as old-age social insurance system, is organized and operated by the state based on some regulations to provide the income for old-age population after their retirement. The aim of the pension system is to protect elderly people from poverty and to provide adequate income for them after retirement.

Medical insurance system is regulated by the state laws in China, and all the urban workers are mandatory to participate in the system. The contribution is from employers and employees together. The aim of the medical insurance is to share the financial burden with the individuals for the cost of medical care.

Unemployment insurance system is also regulated by the state laws and mandatory to all the urban workers in China. The contribution to this system is from employers and employees together during the employment. The aim of the system is to provide temporary income for the individuals who lose their jobs.

Maternity insurance system is designed for the female works who are pregnant during their employment. It is guaranteed by the state laws in China, and all the female workers are supposed to participant in this system. The contribution to system is solely from employers. The system provides the income for the female workers and pays out the cost for the medical care during their maternity.

Disability insurance system in China is regulated by the state laws, and is designed to protect all the workers from damages caused by their work, which could lead to their disability or death. The contribution to this system is solely from the employers. It aims to provide the income compensations to the disabled workers or to their families.

The five parts of the social security system in China is operated separately, and the fund in each one is managed independently from others.

Appendix D

Average Weighted Ages for Pensions and Contributors

According to Boado-Penas et al. (2008) and Settergren and Mikula (2005), the formulae to calculate the average weighted age for the pensioners, A_t^r , and the average weighted age for the contributors, A_t^c , is shown as below:

$$A_t^r = \frac{\sum_{k=0}^{w-1-x_e-A}(x_e + A + k)P_{(x_e+A+k,t)}N_{(x_e+A+k,t)}}{\sum_{k=0}^{w-1-x_e-A} P_{(x_e+A+k,t)}N_{(x_e+A+k,t)}} \tag{D.1}$$

$$A_t^c = \frac{\sum_{k=0}^{A-1}(x_e + k)y_{(x_e+k,t)}N_{(x_e+k,t)}}{\sum_{k=0}^{A-1} y_{(x_e+k,t)}N_{(x_e+k,t)}} \tag{D.2}$$

Appendix E

Mortality Table for China

Table E.1 shows the mortality tables for China during the period 2007-2012, sources are from China Population and Employment Statistics Yearbook (Ministry of Human Resources and Social Security of the People's Republic of China, 2012a).

Table E.1: Mortality Table for China

Age	2007	2008	2009	2010	2011	2012
0	0.009382	0.013641	0.007098	0.003816	0.010435	0.003430
1	0.001504	0.002027	0.001390	0.001113	0.000809	0.001070
2	0.000720	0.001152	0.000590	0.000627	0.000351	0.000630
3	0.000543	0.001066	0.000908	0.000452	0.000361	0.000620
4	0.000781	0.000708	0.000415	0.000370	0.000230	0.000500
5	0.000726	0.000424	0.000150	0.000333	0.000311	0.000100
6	0.000524	0.000314	0.000467	0.000318	0.000150	0.000200
7	0.000049	0.000223	0.000310	0.000285	0.000471	0.000170
8	0.000387	0.000215	0.000133	0.000283	0.000645	0.000270
9	0.000579	0.000366	0.000522	0.000282	0.000580	0.000260
10	0.000316	0.000326	0.000498	0.000305	0.000100	0.000000
11	0.000065	0.000531	0.000358	0.000293	0.000370	0.000200
12	0.000199	0.000369	0.000110	0.000301	0.000127	0.000310

13	0.000234	0.000515	0.000210	0.000294	0.000398	0.000080
14	0.000411	0.000406	0.000297	0.000304	0.000347	0.000150
15	0.000243	0.000170	0.000255	0.000344	0.000322	0.000060
16	0.000391	0.000448	0.000211	0.000350	0.000450	0.000250
17	0.000215	0.000803	0.000189	0.000390	0.000234	0.000330
18	0.000426	0.000429	0.000435	0.000413	0.000395	0.000500
19	0.000515	0.000640	0.000441	0.000426	0.000484	0.000410
20	0.000392	0.000865	0.000391	0.000466	0.000296	0.000510
21	0.001194	0.000891	0.000880	0.000472	0.000524	0.000490
22	0.001192	0.000551	0.000766	0.000497	0.000594	0.000320
23	0.001019	0.000804	0.000406	0.000537	0.000356	0.000330
24	0.000865	0.000594	0.000253	0.000563	0.000234	0.000530
25	0.000454	0.000977	0.000796	0.000583	0.000363	0.000300
26	0.000918	0.000521	0.000972	0.000573	0.000585	0.000900
27	0.001226	0.001068	0.000345	0.000594	0.000403	0.000350
28	0.000733	0.001024	0.000474	0.000611	0.000400	0.000760
29	0.001223	0.000574	0.001439	0.000681	0.000633	0.001050
30	0.000997	0.001597	0.000672	0.000699	0.000761	0.000780
31	0.001153	0.001008	0.001379	0.000770	0.000766	0.000430
32	0.001083	0.001399	0.001104	0.000806	0.001263	0.000680
33	0.001312	0.001494	0.000868	0.000828	0.000594	0.001180
34	0.001003	0.001046	0.001039	0.000944	0.000870	0.001480
35	0.001162	0.001703	0.001112	0.001027	0.000818	0.001860
36	0.000870	0.001270	0.001023	0.001064	0.001195	0.000610
37	0.001202	0.001353	0.001010	0.001135	0.000888	0.001280
38	0.001605	0.000914	0.001248	0.001206	0.001787	0.001110
39	0.001595	0.001301	0.001464	0.001341	0.001691	0.001660
40	0.002008	0.001540	0.001526	0.001510	0.001508	0.001380
41	0.001933	0.002305	0.001580	0.001553	0.001199	0.001480
42	0.001925	0.001877	0.001689	0.001821	0.002470	0.001730
43	0.002655	0.001851	0.001527	0.001888	0.001555	0.002060
44	0.002464	0.002046	0.002168	0.002065	0.001799	0.001890
45	0.001429	0.001975	0.002385	0.002314	0.002582	0.002310
46	0.001913	0.002068	0.002262	0.002360	0.003264	0.002730
47	0.003955	0.002562	0.003632	0.002537	0.002478	0.002170
48	0.002998	0.003379	0.001546	0.003112	0.002394	0.002580
49	0.003881	0.003744	0.003078	0.003281	0.002869	0.003200
50	0.003814	0.003782	0.004020	0.003639	0.005304	0.004480
51	0.004285	0.003699	0.004207	0.003755	0.003688	0.003620
52	0.003597	0.004288	0.003394	0.003979	0.005034	0.005020
53	0.003411	0.004270	0.003998	0.004413	0.004586	0.005140
54	0.005189	0.003933	0.004739	0.004984	0.006283	0.005140
55	0.004093	0.005615	0.004454	0.005179	0.005025	0.005470
56	0.004766	0.005861	0.005625	0.005636	0.006813	0.006220

57	0.006226	0.004716	0.005679	0.006094	0.005913	0.005580
58	0.007305	0.007203	0.005924	0.006807	0.006144	0.008150
59	0.007850	0.008332	0.006620	0.007666	0.006676	0.009020
60	0.006426	0.009514	0.007649	0.008542	0.008894	0.008800
61	0.006430	0.008500	0.006787	0.009377	0.009762	0.010920
62	0.010709	0.009701	0.008598	0.010382	0.009968	0.011440
63	0.010576	0.013414	0.012679	0.011121	0.010938	0.011830
64	0.012945	0.013065	0.009877	0.013011	0.012571	0.013130
65	0.015435	0.016016	0.013171	0.014211	0.015563	0.012010
66	0.014721	0.014724	0.016112	0.014737	0.017337	0.016570
67	0.015670	0.015327	0.014051	0.017229	0.019364	0.015150
68	0.024403	0.020020	0.017182	0.018644	0.018782	0.017650
69	0.023120	0.025351	0.017980	0.021914	0.020299	0.021680
70	0.026069	0.024899	0.023742	0.025568	0.021555	0.027200
71	0.029776	0.028286	0.022409	0.026728	0.023802	0.025670
72	0.033060	0.030809	0.023164	0.030942	0.031732	0.023760
73	0.030337	0.033404	0.031816	0.033591	0.029274	0.035650
74	0.031351	0.035411	0.032349	0.037445	0.033635	0.036440
75	0.044108	0.040308	0.039139	0.041511	0.035214	0.035930
76	0.046360	0.044637	0.038169	0.042191	0.048242	0.045610
77	0.042329	0.057323	0.046692	0.050969	0.059107	0.049840
78	0.055301	0.047889	0.052871	0.056201	0.049494	0.059950
79	0.059623	0.047896	0.049547	0.062121	0.061037	0.067640
80	0.057569	0.066543	0.057113	0.074281	0.070853	0.069310
81	0.075896	0.063838	0.068459	0.077907	0.065820	0.069610
82	0.072604	0.077971	0.067842	0.085809	0.082526	0.081050
83	0.079189	0.078372	0.091121	0.093518	0.101553	0.086150
84	0.073289	0.091975	0.073148	0.103631	0.088501	0.107900
85	0.089103	0.080704	0.076786	0.111000	0.105687	0.117330
86	0.111240	0.104517	0.092219	0.118879	0.111571	0.129940
87	0.094742	0.125280	0.105737	0.130066	0.126687	0.131620
88	0.130962	0.120150	0.120458	0.144177	0.135291	0.155130
89	0.101231	0.133787	0.121170	0.156873	0.120961	0.191340
90	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

Source from China Population and Employment Statistics Yearbook (Ministry of Human Resources and Social Security of the People's Republic of China, 2012a)

Appendix F

Calculation of Contribution Years

Table F.1 shows the different assumptions for the number of contribution years depending on the entry age to the labour market and the number of non-contribution years.

It is assumed that graduates of junior secondary school start working at the age of 16, of senior secondary school at the age of 18, and of university and beyond at the age of 22. The information on 'Educational attainment for urban employed persons by sex', 'The proportion of female employed persons in urban areas', and 'The proportion of unemployed women for the reason of do housework in urban areas', which are required to calculate the total contribution years, are obtained from China Population and Employment Statistics Yearbook (Department of Population and Employment Statistics, National Bureau of Statistics of China, 2013).

Table F.1: Different assumptions for the number of contribution years

	Baseline scenario	More contribution years	Fewer contribution years
16	10	7	15
22	3	2	5
Total Contribution Years, A	33	35	29

The formula to calculate the total number of contribution years, A, for an individual is shown below:

$$\begin{aligned} A =& \beta_m \sum_{x_e=16}^{22} \left[(x_m^{(r)} - x_e - A^0)\beta_m^e\right] \\ &+ \beta_f \sum_{x_e=16}^{22} \left[(x_f^{(r)} - x_e - A^0)(1-\beta_f^0) + (x_f^0 - x_e)\beta_f^0\right] \beta_f^e \end{aligned} \tag{F.1}$$

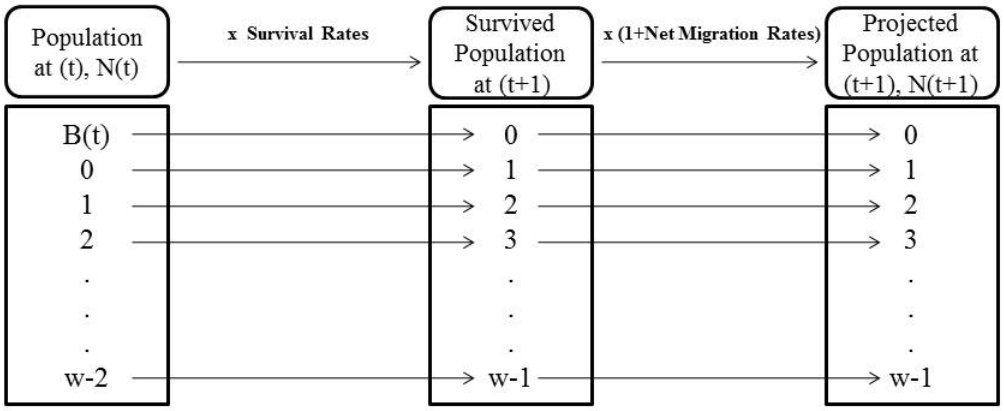
where β_m is the proportion of male contributors in the number of total contributors, while β_f is the proportion of female contributors; x_e is the earliest entry age into the pension scheme; $x_m^{(r)}$ is the legal retirement age for male workers; A^0 is the average non-contribution periods for people who start working at age x_e; β_m^e is the weight of male workers who start working at age x_e; $x_f^{(r)}$ is the legal retirement age for female workers; β_f^0 is the weight of female workers who stop working after marriage; x_f^0 is the average age when female workers stop working after marriage, and β_f^e is the weight of female workers who start working at age x_e.

Appendix G

Illustration of Cohort Component Method

Figure G.1 illustrates the process of the cohort component method. The first step is to estimate the population census at year t, i.e. $N(t)$. The second step calculates the total number of new births during year t, $B(t)$, by taking into account the fertility rates at year t. Then, the survival rates at each age are multiplied to obtain the number of individuals who survived at year $t + 1$. Finally, the net migration rates per age are added in order to calculate the projected population at time $t + 1$, i.e. $N(t + 1)$.

Figure G.1: Illustration of cohort component method



Appendix H

Survival Rates for China

Table H.1 shows the estimated historical survival rates of China over the period 1975-2015 and Table H.2 shows the projected survival rates of China over the period 2015-2090, sources are from United Nations (2015). The survival rates of new births has taken into account the infant mortality at each period.

Table H.1: Estimated survival rates for China, 1975-2015

Age x	Age Interval n	Survival Ratio $s(x,n)$							
		1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015
births	1	0.93799	0.95069	0.95350	0.95610	0.96267	0.97275	0.98218	0.98762
0	5	0.98363	0.98865	0.99002	0.99164	0.99309	0.99544	0.99711	0.99795
5	5	0.99362	0.99510	0.99590	0.99670	0.99728	0.99788	0.99819	0.99848
10	5	0.99580	0.99634	0.99665	0.99699	0.99729	0.99796	0.99825	0.99849
15	5	0.99497	0.99531	0.99552	0.99580	0.99602	0.99704	0.99738	0.99775
20	5	0.99345	0.99415	0.99439	0.99473	0.99503	0.99601	0.99645	0.99686
25	5	0.99167	0.99282	0.99327	0.99371	0.99410	0.99485	0.99531	0.99595
30	5	0.98959	0.99089	0.99166	0.99229	0.99283	0.99342	0.99394	0.99490
35	5	0.98602	0.98757	0.98865	0.98946	0.99037	0.99118	0.99194	0.99313
40	5	0.98008	0.98212	0.98399	0.98496	0.98616	0.98792	0.98876	0.99009
45	5	0.96768	0.97116	0.97505	0.97591	0.97762	0.98161	0.98317	0.98444
50	5	0.94794	0.95336	0.95971	0.96009	0.96257	0.96994	0.97288	0.97411
55	5	0.91520	0.92310	0.93042	0.93277	0.93750	0.94761	0.95231	0.95381
60	5	0.86227	0.87621	0.88500	0.88686	0.89449	0.90816	0.91477	0.91598
65	5	0.78709	0.80492	0.81876	0.81672	0.82620	0.84477	0.85282	0.85590
70	5	0.67694	0.69400	0.70899	0.71970	0.72666	0.74763	0.75830	0.76653
75	5	0.52980	0.54897	0.56654	0.59526	0.60327	0.62539	0.64425	0.65414
80	∞	0.32678	0.33925	0.35532	0.37503	0.39027	0.40949	0.42697	0.43664

Source from United Nations (2015)

Table H.2: Projected survival rates for China, 2015-2090

Age x	Interval n	Survival Ratio $s(x,n)$														
		2015-2020	2020-2025	2025-2030	2030-2035	2035-2040	2040-2045	2045-2050	2050-2055	2055-2060	2060-2065	2065-2070	2070-2075	2075-2080	2080-2085	2085-2090
births	1	0.98977	0.99149	0.99282	0.99384	0.99475	0.99548	0.99610	0.99663	0.99705	0.99738	0.99762	0.99782	0.99799	0.99815	0.99829
0	5	0.99828	0.99855	0.99877	0.99894	0.99910	0.99922	0.99932	0.99941	0.99949	0.99954	0.99959	0.99962	0.99966	0.99968	0.99971
5	5	0.99869	0.99887	0.99904	0.99917	0.99929	0.99938	0.99947	0.99954	0.99960	0.99965	0.99968	0.99971	0.99974	0.99976	0.99979
10	5	0.99867	0.99883	0.99898	0.99910	0.99922	0.99931	0.99940	0.99947	0.99954	0.99959	0.99963	0.99966	0.99969	0.99972	0.99974
15	5	0.99798	0.99819	0.99840	0.99858	0.99874	0.99888	0.99901	0.99913	0.99923	0.99931	0.99937	0.99943	0.99947	0.99952	0.99956
20	5	0.99716	0.99744	0.99773	0.99797	0.99820	0.99840	0.99859	0.99876	0.99890	0.99901	0.99911	0.99918	0.99926	0.99932	0.99939
25	5	0.99632	0.99668	0.99705	0.99736	0.99766	0.99792	0.99816	0.99838	0.99856	0.99871	0.99884	0.99894	0.99904	0.99913	0.99921
30	5	0.99536	0.99581	0.99625	0.99663	0.99700	0.99732	0.99762	0.99789	0.99812	0.99832	0.99848	0.99861	0.99873	0.99885	0.99896
35	5	0.99374	0.99433	0.99490	0.99539	0.99586	0.99628	0.99668	0.99704	0.99736	0.99762	0.99784	0.99803	0.99820	0.99836	0.99851
40	5	0.99097	0.99179	0.99256	0.99323	0.99388	0.99448	0.99504	0.99556	0.99601	0.99640	0.99672	0.99699	0.99724	0.99748	0.99771
45	5	0.98584	0.98710	0.98829	0.98931	0.99032	0.99124	0.99212	0.99294	0.99365	0.99427	0.99477	0.99519	0.99558	0.99596	0.99632
50	5	0.97645	0.97857	0.98055	0.98225	0.98395	0.98550	0.98698	0.98835	0.98954	0.99057	0.99141	0.99212	0.99277	0.99340	0.99399
55	5	0.95797	0.96183	0.96550	0.96864	0.97173	0.97460	0.97730	0.97978	0.98192	0.98378	0.98530	0.98658	0.98774	0.98885	0.98989
60	5	0.92345	0.93048	0.93728	0.94312	0.94880	0.95410	0.95907	0.96361	0.96749	0.97087	0.97365	0.97598	0.97807	0.98007	0.98193
65	5	0.86811	0.87969	0.89099	0.90070	0.91025	0.91920	0.92762	0.93534	0.94193	0.94771	0.95251	0.95652	0.96011	0.96356	0.96678
70	5	0.78382	0.80101	0.81811	0.83274	0.84731	0.86132	0.87457	0.88682	0.89743	0.90685	0.91480	0.92147	0.92747	0.93326	0.93871
75	5	0.67499	0.69590	0.71795	0.73703	0.75616	0.77502	0.79332	0.81048	0.82563	0.83951	0.85149	0.86168	0.87096	0.87997	0.88856
80	∞	0.45233	0.46696	0.48320	0.49777	0.51272	0.52768	0.54250	0.55670	0.56955	0.58198	0.59325	0.60313	0.61244	0.62168	0.63073

Source from United Nations (2015)

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