Population Ageing and the Impact of Later Retirement on the Pension System in China: An Applied Dynamic General Equilibrium Analysis

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Abstract

China's population is rapidly ageing because of the sustained low fertility and increasing life expectancy. At the end of 2019, the elderly 65 and older accounted for 12.6 percent of the total population, compared to around seven percent in 2000. It will continue to increase to 31 percent in 2050. Rapid ageing imposes a big challenge to sustainable growth. The Chinese government is considering increasing the retirement age as a remedy to the challenge of population ageing.

Using a dynamic general equilibrium model of the Chinese economy, this paper explores the implications of raising the retirement age on economic growth and pension sustainability in China over the period of 2020 to 2100. In the baseline scenario, we assume that China maintains its current retirement age. The simulation results reveal that growth in the labour force would turn negative because of population ageing. Thus China has to rely on technology improvement and capital stock increases to support its economic growth. Without reforming the current pension system, China's pension account will accumulate huge debts. The debt plus the interest obligation will put high pressure on the general government budget. By the end of this century, the general government budget deficit will reach to 22 percent of GDP.

In the policy scenario, we assume that China will gradually increase the retirement age from 58 to 65 years old starting from 2020. The simulation results show that increasing the retirement age is a powerful policy in the short to medium term. It will boost China's economic growth and reduce the pension fund deficit significantly because it will not only increase the labour force but also reduce the number of pensioners by delaying them access to the pension fund. However, the effectiveness of the policy depends on how much the labour force participation rate for people aged 58 to 65 can be increased.

Keywords: Population ageing, retirement age, labour force participation, pension, economic growth, CGE model

JEL classification: J11, J26, C68

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1 Introduction

Population in China is ageing rapidly because of the sustained low fertility and increasing life expectancy. At the end of 2019, the elderly 65 and older accounted for 12.6 percent of the total population, compared to about 4.9 percent in 1982 and seven percent in 2000 (NBS 2019).

Population aging has profound and long-lasting impacts on a country's economic growth. Ageing implies a slower or even negative growth of working-age population, driving up the scarcity and the costs of labour. Based on the life cycle hypothesis (Modigliani, 1966), ageing also implies a lower saving rate or investment rate of the economy. The process of aging is often accompanied with a country's changing competitive advantage in the international markets, and hence leading to the re-adjustment of the sources of growth and the industrial structure of the economy.

China's fertility decline and the consequent "demographic bonus" as featured by increased working-age population relative to the dependent population had contributed to China's economic miracle of startling growth for decades (Cai, 2010). However, the progressive aging of the population has been turning the demographic bonus into "demographic deficit," presenting severe challenges to the country's future development. One of such challenges is the financial sustainability of the country's public pension system.

1.1 China's pension system and the impact of population ageing on its sustainability

In the present, there are two public pension schemes in China: the Basic Pension for Urban Employees (PUE) and the Basic Pension for Urban and Rural Residents (PURR). Let us first have an overview of these two schemes.

1.1.1 The Basic Pension for Urban Employees (PUE)

PUE was restructured in mid-1990s from the Labour Insurance scheme (*lao bao*) introduced in China's planned economy era (State Council, 1991, 1995 and 1997). In its early stage of development, PUE covered only the employees of state owned enterprises (SOEs). It gradually extended to cover the employees of foreign-funded enterprises and private enterprises, and urban self-employed (State Council, 2005). Its coverage further extended to urban peasant workers since July 2011, as mandated by "Social Insurance Law" (The Standing Committee of the National People's Congress, 2010). In 2015, it merged with the pension component of the Government Insurance (*gong fei*) for the employees of the government and public institutions (State Council, 2015).

PUE is pooled and operated at the prefecture-level localities. By design, it is a combination of social pooling and individual saving accounts. The social pooling pillar is a pay-as-you-go (PAYGO), defined benefits (DB) system and financed by employers' contribution which equals to 16% of the total payroll.[1] Some provinces with advantage of large in-flow of migrants, such as Guangdong and Zhejiang, are able to lower the contribution rates to around 14 percent.

[1] It was 20 percent for many years prior to May 2019, when the Central government decided to lower the contribution rate as one of the measures to lower the tax and fee burden of the enterprises in China (General Office of the State Council, 2019).

The pillow of individual saving accounts is a funded, defined contribution (DC) system financed by employees' contributions equal to 8 percent of their individual wages. Those workers who have participated in the scheme and made contribution to the pension funds for at least 15 years upon retirement are entitled to receiving benefits from the social pooling pillar. The benefits are calculated based on their years of contribution, their own wages, and the average wage in the locality. For the benefits derived from their individual saving accounts, they can get annuity equal to the balance of their individual saving accounts upon retirement divided by the government-defined number of months reflecting the remaining life expectancy at retirement.

Employees who had contributed to the pension fund for less than 15 years upon retirement are not entitled to receiving benefits from the social pooling pillar. They can receive only a lump-sum payment equal to the balance of their individual saving accounts upon retirement.

In practice, the determination of pension benefits is more complicated due to the transitional arrangements described in the pension reform package in 1996, and the annual growth of pension benefits mandated by the government regardless of the benefit-defining rules.

Although PUE has been set up in prefecture-level localities all over the country since late 1990s, its high contribution rates tend to exclude the low-income rural workers and self-employed from participating in the scheme, resulting its low coverage of these groups. As revealed by the Ministry of Human Resources and Social Security and (MOHRSS 2019), at the end of 2018, PUE covered 301.04 million working employees and 117.98 million retirees, totalling 419.02 million participants. In 2018, the PUE had total revenues ¥5116.8 billion [2] and total expenditures ¥4464.5 billion, generating an annual surplus ¥652.3 billion, and the accumulated surplus ¥5090.1 billion.

1.1.2 The Basic Pension for Urban and Rural Residents (PURR)

In 2014, the State Council (2014) decided to merge the two pension schemes, the New Rural Pension and the Pension for Urban Residents, into one unified pension scheme for urban and rural residents, named "Basic Pension for Urban and Rural Residents" (PURR). This might be one of the policy efforts to reduce the rural-urban income disparity and to facilitate the rural-urban mobility.

The PURR has three sources of revenues: the government subsidies, individual contributions, and the rural collective subsidies if available at all. The central government sets a minimum standard pension benefit[3] for all eligible elderly nationwide. This minimum-standard benefit is

[2] This data source does not disclose the government subsidies to the PUE in 2018, as it did for 2017 and earlier years. The government subsidies accounted for 18.57 percent of the PUE's total revenues in 2016 and 18.48 percent in 2017. Assuming that the government subsidies accounted for 18.5 percent of the total revenues in 2018, then these subsidies would be ¥946.61 billion, surpassing the surplus ¥652.3 billion by nearly ¥300 billion.

[3] The minimum standard of basic pension was Y55 in 2014, Y70 in 2015-2017, and Y88 in 2018 and onward (MOHRSS, 2015, 2018).

100 percent financed by the central government for the western and middle provinces, and 50 percent is financed for the eastern provinces. The provincial/local governments are encouraged to provide additional pension benefits with their own sources of funding.

The participants are mandated to contribute to their own individual accounts, at their choices of annual contributions among 12 options: ¥00, ¥200, ¥300, ¥400, ¥500, ¥600, ¥700, ¥800, ¥900, ¥1000, ¥1500, and ¥2000. Local government should subsidize each participant's contribution by at least ¥30 per year. The average annual contribution per participant have remained very low, increasing from ¥177.59 in 2011 to ¥205.75 in 2016. The individual accounts of the scheme are funded and based on defined contribution.

When participants retire, they can receive from their individual accounts monthly pension benefits which equal to the total balance in the accounts upon retirement divided by the number of months and then further divided by 139.

The rural collective enterprises, charitable organizations and other NGOs are also encouraged to subsidize the individual contributions in a transparent way.

Among the three sources of revenues, the government subsidies have remained the predominant source, accounting for over three quarters of the total revenues of the scheme. At the end of 2018, PURR covered a total of 523.92 million participants, including 158.98 million pensioners, of which 21.96 million were urban and rural elderly in poverty. In 2018, PURR had total revenues ¥383.8 billion[4] and total expenditures ¥290.6 billion, generating annual surplus of ¥93.2 billion and accumulated surplus ¥725 billion (MOHRSS, 2019).

1.1.3 The impact of population ageing on the sustainability of the pension system

Population aging and the decline of the system support ratio. Population aging has adverse effects on the financial sustainability of pension system. To elaborate a bit on this point, let us introduce two related indicators: the "potential support ratio" of a population and the "system support ratio" of a pension scheme.

The potential support ratio is the ratio of working-age population aged 15-64 to the elderly population 65 and older.[5] As one of the consequences of ageing, In China the potential support ratio has been declining since early 1980s. It fell from 12.53 in 1982 to 8.40 in 2010 and further to 5.62 in 2018. The United Nations' medium variant projection shows that the potential support ratio would fall to 2.29 in 2050 and 1.70-1.80 in the last two decades of the century (United Nations 2019).
For a pension scheme, a similar but more precise indicator is the "system support ratio," defined as the ratio of the working employees to the retirees in a pension scheme. It is easy to derive

[4] Again this data source does not disclose the government subsidies to the PURR in 2018, as it did for 2017 and earlier year.
[5] "Potential support ratio" is just the reciprocal of the "old-age dependency ratio," defined as the ratio of the elderly population 65 and older to the working-age population 15-64.

that for a PAYGO pension scheme, if its total revenue is in balance with its total expenditure, then the following equation shall hold[6]:

$$\text{The replacement ratio} = \text{contribution rate} * \text{system support ratio}$$

Where the replacement ratio is the ratio of the average pension benefit to the average wage, the contribution rate is the percent of the workers' wages should be contributed to the pension fund. For instance, suppose that the contribution rate is 12 percent, and the system support ratio is three, then there are three workers to support one retiree. The three workers will contribute on average 12%*3=36 percent of the average wage. If all the contribution revenues are used to pay the pension benefits, then each retiree will receive on average pension benefits equal to 36 percent of the average wage.

In the above equation, if the system support ratio declined, then to make its revenues meet its expenditures, the pension scheme has to either increase the contribution rate or cut the replacement ratio, or combination of both. Nevertheless, all these measures would be politically controversial and painful.

China's population aging and the corresponding decline of the system support ratio have driven up the deficits of china's pension schemes.

The increased deficits of the PUE In recent years the share of contributions among the PUE's total revenue fell from 82.33 percent in 2012 to 76.35 percent in 2016. For the country as a whole, the PUE' contributions have been surpassed by the total expenditures since 2013. In the meantime, the government's pressures to fill the gap between the revenues and expenditures have been increasing.

The above data describe the overall revenues and expenditures of the PUE without distinguishing the funded individual saving accounts from the social pooling pillar based on PAYGO. The fact is, however, huge amount of funds in the individual accounts have been used to pay pension benefits, rather than being used in investment to get returns. This practice created the problem of "empty accounts." In 2015, the PUE's empty individual accounts accumulated to ¥4714.4 billion, exceeding the scheme's accumulated surplus of ¥3534.5 billion (Zheng, 2016). It can be expected that the accumulated surplus of the scheme will be exhausted in the near future.

In addition, since the PUE is pooled at the prefecture-level localities, the financial situations of local pension pools tend to be worse than the national aggregate. The massive flow of migrant workers from the inland to coastal provinces creates transfers of pension contributions from

[6] For a PAYGO pension system, if its expenditures meet its revenues, then
the average pension benefits * retirees = the average wages * contribution rate * working employees
The left-hand side of the equation is the expenditures on pension benefits, and the right-hand side is the revenues from the working employee's contributions. Divided both side by average wages and working employees, then by definition of replacement ratio and the system support ratio, we get the replacement ratio = contribution rate * system support ratio.

the origin to the destination places. These transfers in turn have created financial difficulties in the inland provinces. In 2015, out of 31 provinces in China, 24 ran deficits if government subsidies were not taken into account; only seven provinces, including Guangdong, Beijing, Zhejiang, Jiangsu, Shandong, Fujian and Xizang, mostly in the coastal provinces, had surpluses (Zheng, 2016).

Studies on the implicit pension debts (IPD) Several studies (Zuo & Zhou, 1995; World Bank, 1997; Wang, Xu, Wang & et al, 2001) have projected the PUE's contributions and expenditures, and estimated the implicit pension debt. In a recent study on China's national balance sheet, Ma, Zhang, Li & et al (2012) conclude that in the baseline scenario, if there are no reforms, the deficits in the PUE would become a heavy fiscal burden. In 2050 the present value of total deficits over 2013-50 would sum to 83 percent of 2011's GDP. This study did not take into account of the deficits in PURR; otherwise the burden on fiscal expenditures would be even heavier.

1.2 Enhancing Financial Sustainability of China's pension system: Policy options and later retirement

1.2.1 Policy options to enhance financial sustainability of the PUE

China's population aging and the deteriorating financial sustainability of the country's pension system have activated discussions on the responsive policies. The proposed policy options include, among others, to implement nationwide social pooling pillar of the PUE; to lower the mandatory contribution rate to achieve higher participation rate of the PUE, to link the participants' pension benefits more closely to their contributions, and to mandate later retirement.

Among all these options, later retirement is an efficient one. It can on the one hand reduce the number of retirees and hence the expenditures on pension benefits, and on the other hand increase the number of working employees and hence the contributions to the scheme. The following sections of this paper will focus on the study of the later retirement in the framework of general equilibrium modelling.

1.2.2 Discussions on later retirement

Late retirement as a policy option has drawn much attention, because the mandatory retirement in China has been quite early. The present retirement age in China's urban sectors is 60 for men, 50 for woman workers, and 55 for woman officials. For those workers who are engaged in physically demanding or hazardous jobs should retire five-year earlier, that is, 55 for men and 45 for women (Ministry of Labour and Social Security, 1999). This standard was set in 1953, when the life expectancy was only about 40 years in China. It was almost doubled to 77 years in 2018 (National Health Commission, 2019), whereas the mandatory retirement age remains unchanged.

In spite of China's rather early retirement, the country's Labour Force Participation Rate (LFPR) remained high in the era of planned economy. However, the LFPR has declined since the 1980s. During 2005-2015, for instance, LFPR of men fell from 78 percent to 74 percent while LFPR of women fell from 63.5 percent to 56.0 percent (Lu, 2019).

Some studies (e.g. MA , LV & Ye, 2010). find that the LFPR decline among the younger people aged 15-24 is closely related to longer years of schooling, especially in the higher education while the sharp decline of LFPR among the older persons associated with early retirement. The LFPR of men fell to about 60 at age 60-64 and that of women fell to 30-56 percent at age 55-59, compare with the high level of 94-99 percent for men and 75-85 per cent for women at age 25-49. Obviously, later retirement policy will help to improve the LFPR of the older persons.

Given the difficulties in the financing of the PUE scheme, it is natural to think of later retirement as an attractive policy option. An important official document claimed later retirement as one of the reform measures to enhance China's pension system (CPC Central Committee, 2013). However, the operational details of such reform have not been publicized so far. It seems that the government has been hesitated to carry out such reform, perhaps due to the concern over its impacts on the employment of the younger cohorts, and over the public cry in the internet against the reform.

However, population aging and the deteriorating financial sustainability of the pension system necessitate the later retirement policy. This paper is aimed to explore the implications of later retirement on economic growth and pension sustainability in the framework of CGE modelling.

2 Methodology and modelling framework

2.1 CHINAGEM model and its core theory, structure and dynamic mechanism

The model we used in this paper is a revised version of CHINAGEM – a dynamic computable general equilibrium model of the Chinese economy. The original database of the CHINAGME model includes 142 sectors and its base data reflects the 2012 input-output structure of the Chinese economy. The core CGE structure is based on ORANI, a static CGE model of the Australian economy (Dixon et al 1982). The dynamic mechanism of CHINAGEM is based on the MONASH model of the Australian economy (Dixon and Rimmer, 2002). The CHINAGEM model captures three types of dynamic links: physical capital accumulation; financial asset/liability accumulation; and lagged adjustment processes in the labour market.

In CHINAGEM, production is modelled using nested constant elasticity of substitution (CES) and Leontief production functions which allow substitution between domestic and imported sources of produced inputs and between labour, capital and land. The production functions are subject to constant returns to scale. Household demand is modelled by the Extended Linear Expenditure System (ELES). Trade is modelled using the Armington assumption for import demand and a constant elasticity of transformation (CET) for export supply. China is considered as a small open economy in import markets with foreign import prices determined

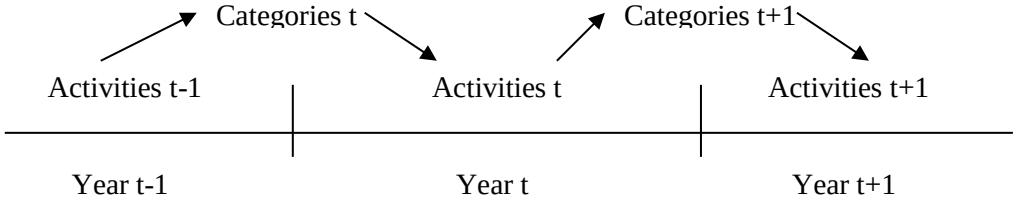
in world markets. Exports are demanded according to constant-elasticity demand curves for most commodities. In the model, capital stock is accumulated through investment activities (net of depreciation). Investors respond to changes in the expected rate of return.

2.2 Extension of CHINAGEM model

2.2.1 Labour market module

The original version of CHINAGEM lacks the capacity to model pension issues in detail. In this version, there is only one type of labour and no pension account and government account. Given that different type of labour in China is eligible to participate in different pension insurance scheme, so it is necessary to have different labour types in the model. In this paper, following Dixon et. al (2011) and Mai et.al (2013) we introduced a labour market module into CHINAGEM model. The labour market module is designed to capture China's unique household registration system and other institutional barriers in the labour market. Two crucial concepts in the CHINAGEM labour market module are categories and activities of labour supply. At the start of year t, labour that will be available during the year are allocated to categories of labour supply. The categories are determined mainly on the basis of employment during the preceding year (t-1). Activities in year t are what people do in that year. The relationship between activities and categories is illustrated in Figure 1.

Figure 1: Labour market dynamics



The labour market module contains ten labour supply categories: five employment categories, three unemployment categories, and two new entrant categories (Table 1). The first eight of these categories are associated with corresponding activities. For example, the category AG for year t refers to the number of employment in rural agriculture in year t-1 that is still available for employment in year t. The activity AG for year t refers to the number of labourers actually absorbed in rural agricultural employment in year t. Most of the AG-category labour in year t is employed in activity AG in year t. However, some AG category labour may flow to other activities, and some labour from other categories may flow to the AG activity.

Different categories have different labour supply behaviour and there are different degrees of mobility between categories. We treat the entire rural labour force as unskilled workers and we assume that all rural employment and unemployment categories can only make offers to work in rural activities (AG, RNAG, and RUE) because of China's household registration (hukou) system. But rural new entrants (NRUR) can make offers to rural as well as urban activities. This is based on the assumption that some urban enterprises recruit new entrants from rural areas and grant them urban household status. Rural new entrants with university degrees may

acquire a job in a skilled urban occupation and obtain urban household status.

Table 1: Categories and Activities

	Employment categories and activities
AG	**AG**riculture - Person-years of employment in rural agriculture sectors with rural residential status
RNAG	**R**ural **N**on-**AG**riculture – Person-years of employment of rural people in non-agriculture industries within their township of residence, such as in township and village enterprises and private enterprises in rural areas
RUE	**R**ural-**U**rban **E**mployment – Person-years of employment of rural people in non-agriculture industries outside of their township of residence
UUSE	**U**rban **U**n**S**killed **E**mployment – Person-years of employment of urban people in unskilled occupations
USE	**U**rban **S**killed **E**mployment – Person-years of employment of urban people in skilled occupations
	Unemployment categories and activities
RAGU	**R**ural **AG**ricultural **U**nemployment – Person-years spent by rural workers without a job in their township of residence
RUU	**R**ural-**U**rban **U**nemployment – Person-years spent by rural workers without a job outside their township of residence
UU	**U**rban **U**nemployment – Person-years of urban labour force that are not employed
	New entrants categories (no corresponding activities for these categories)
NRUR	**N**ew entrants **RUR**al – Person-years of new entrants into labour force with rural residential status
NURB	**N**ew entrants **URB**an – Person-years of new entrants into labour force with urban household status

For the urban labour force we disaggregate into two employment categories, urban skilled employment (USE) and urban unskilled employment (UUSE); one unemployment category (UU); and one new entrant category (NURB). We assume that urban categories make offers only to urban activities (UUSE and USE). We assume no voluntary unemployment in China. Consequently, no category makes offers to unemployment. We summarize the labour supply categories and activities in Table 1.

The number of persons employed in an activity in the current year is determined by the demand for and supply of that activity. Those who make an offer to an employment activity but do not

get a job in that activity will be forced back to their previous employment activity or to the relevant unemployment activity.

The labour market module of the CHINAGEM model has the following equation blocks:

- demand for and employment of labour by activity;
- supply of labour by category;
- wage adjustment reflecting the gap between demand and supply;
- the determination of everyone's activity in year t; and
- linking the number of people in activity o in year t to the number of people in category c in year t+1.

Please refer to Mai et al (2014) for a formal presentation of the labour market module.

The category of labour supply in the labour market module is consistent with China's pension insurance schemes. Based on the relevant statistics, we assume that all the urban skilled workers (USE) and 80 percent of the urban unskilled employment (UUSE) workers participate in the Basic Pension for Urban Employees -PUE (Scheme 1)[7]. The rest of 20 percent of UUSE worker participates in the Basic Pension for Urban and Rural Residents - PURR (Scheme 2) (see Table 2). PURR may include some self-employed urban workers and some workers who are employed in the small private factories or companies.

For the rural-urban migrant workers (RUE), according to the Statistical Bulletin on Human Resources and Social Security Development of China there was around 262.61 million RUE workers in the urban area in 2012 (Ministry of Human Resources and Social Security of the PRC, 2012). However majority of them were not covered by the Basic Pension for Urban Employees[8] (Ministry of Human Resources and Social Security of the PRC, 2013). There are many reasons for the low participation rate: (1) high contribution rate. Since RUE workers' in general earn low wages, the high contribution rates tend to discourage them from participating in the scheme; (2) unstable job. The nature of RUE workers implies that their jobs are relatively not very secure. Changing job or moving back to their home villages after a short period of work in the urban area is very common for RUE workers (Shi and Chen, 2017). Therefore, majority of RUE workers are reluctant to participate in the PUE; (3) Portability problems. Based on the currently policy, when RUE workers move across the boundary of localities, they

[7] In 2012 China's total urban employment was 371.02 million including 163.36 million migrant rural workers and 207.66 million local urban employees (non-migrant rural workers). In the same year, the PUE covered 229.811 million urban employees, including 45.43 million migrant workers and 184.38 million local employees. We can thus calculate that the participation rate of migrant workers was 27.81 percent, and that of local employment was 88.79 percent. We assume that the skilled workers accounted for 20 percent of local urban employees, and their participation rate is 100 percent; unskilled workers accounted for 80 percent of local urban employees, and their participation rate can be calculated as 85.99 percent. Due to the high mobility of migrant workers and urban unskilled workers and the consequent interruption to their pension participation, in the model we lower the participation rate of migrant workers to 25 percent and urban unskilled workers to 80 percent.

[8] According to the Ministry of Human Resources and Social Security (2013), in 2012 there were a total of 26.26 million RUE, among which 16.33 million were out-migrants. Only 45.43 million RUE were covered by the PUE, accounting for 17.3 percent of the total and 27.8 percent of the migrants.

would have difficulties to carry with them their entitlement to the benefits from the social pooling accounts in the places of origin.. This portability problem discourages RUE workers to participate in the PUE.

Table 2: China's current pension system -- coverage of each pension scheme

Labour category	Basic Pension for Urban Employees (Scheme 1)	Basic Pension for Urban and Rural Residents (Scheme 2)
USE	100%	---
UUSE	80%	20%
RUE	25%	75%
AG	---	100%
RNAG	---	100%
UU	---	100%
RAGU	---	100%
RUU	---	100%
REST*	---	100%

Please note: REST* includes the urban and rural new entrants (NURB and NRUR) and the rest of all labour force and residents who does not include in the labour categories in Table 1.

We assume that all the agricultural workers (AG) and rural non-agricultural workers (RNAG) participate in PURR or Scheme 2, so do all unemployed workers including UU, RAUU, RUU, urban and rural new entrants, and the rest of urban and rural residents (REST) as shown in Table 2.

2.2.2 Pension module

The pension module we developed for this study captures China's current pension system. As we discussed in part one, the system includes two schemes: 1) The Basic Pension for Urban Employees (scheme 1 or PUE) and 2) The Basic Pension for Urban and Rural Residents (scheme 2 or PURR). Scheme 1 includes two pillars: the social pooling pillar and the individual saving accounts. Scheme 2 includes two pillars as well. However the second pillar is quite small in the scheme[9] (Social Insurance Management Center, Ministry of Human Resources and Social Security of the PRC, 2014), so in the current version of pension module, we ignore pillar two and only consider pillar one in scheme 2.

[9] Data source: Annual report on the Development of Social Insurance in China (2014) [M], China Labour and Social Security Publishing House, 2014:27. According annual report on the development of social insurance in China, individual account pension expenditure only accounts for 9.9 percent of urban and rural residents basic pension expenditure.

2.2.2.1 Basic Pension for Urban Employees – Scheme 1

- ***Pillar one***

We first define the contribution by labour category to pillar one:

$$CONTRIBUTION1\_1(o)_t = CRATE1 * Wagelevel(o)_t * Emperson(o)_t * COVERAGE\ (o) * P\_ACON\_P1\_O1_t \quad (1)$$

Where $CONTRIBUTION1\_1(o)_t$ is the contribution made to pillar one, Scheme 1 at yeat t by labour catogory o, refering to the labour catogory of USE, UUSE and RUE. $CRATE1$ is the contribution rate which is 20 percent of their wage for these labour catogories. $Wagelevel(o)_t$ is the wage level of catogory o in year t. $Emperson(o)_t$ is the total number of employed persons of catogory o in year t. $COVERAGE\ (o)$ is the coverage (participation) rate of catogory o in this scheme. As we discussed in the last section, the participation rate of USE, UUSE and RUE is 100 percent, 80 percent, 25 percent for USE, UUSE and RUE, respectively. $P\_ACON\_P1\_O1_t$ is the compliance rate in year t. Some wokrers partipated in the sheme but did not regularly pay the contribution or stop paying contrbution after contributing several years beffore meeting the minimum 15 consecutive years' contribution requirement. Here the compliance rate is the actual participation rate after excluding those participants. The compliance rate from 2012 to 2016 is calculated by using historical data. From 2017 and onwards, we assume that the compliance rate remains at the 2016 level.

$$Stock1\_1_t = Stock1\_1_{t-1}(1 + IntRate) + \sum_o Contribution1\_1(o)_t + Government1\_1_t - \sum_o Payment1\_1(o)_t \quad (2)$$

Equation 2 is the eqaution about the pension stock of pillar one, Scheme 1. It says that the pension stock in year t is last year's stock plus the interest earned, the workers's contribution and government subsidies in year t, then subtract the payment to retired eligible workers in year t. Where $Stock1\_1_t$ and $Stock1\_1_{t-1}$ is the pension stock of pillar one in year t and year t-1, respectively. IntRate is the interest rate of the economy. $\sum_o Contribution1\_1(o)_t$ is the sum of contibution paid by different labour catogory o in year t. $Government1\_1_t$ is the government subsidies to pillar one in year t. $\sum_o Payment1\_1(o)_t$ is the sum of payment to retired workers by labour catogory o in year t.

Based on China's current pension policy, the pension payment is paid to eligible workers based on which year the eligible worker started to work and which year the eligible workers retired. The eligible workers who retired before 1996 is called "old pensioners". Their pension payment in year t is simply the fourty percent of the average wage level in year t. We did not disaggregate pension payment to the "old" workers by their labour catogory becuase the goverment pays these workers 40 percent of the current year average wage level regardless of their labour catogory. Furthermore, there is no rural-urban migrant workers (RUE) includeded in these "old" workers.

$$Payment\_Old_t = Wagelevel_t * 40\% \quad (3)$$

Where $Payment\_Old_t$ is the payment in year t to eligible "old workers" who were retired before 1996.

For the "new" workers who started working in 1996 or later at labour catogory o, their pension payment for pillar one in year t $Payment\_New(o)_t$ is one percent of their wage level in year t-1 time years worked. Every eligible worker may have different span of working years when he/she retires (equation 4). In this paper, we use the avegage span of working years for all labour catogorie. The avegage span of working years is calabrated in the model from year 2013 to 2016 based on the actutal pension payment data and number of workers who received pension payment from this scheme. For the year 2017 and onwards, we assume that span of working years remains the same as in year 2016.

$$Payment\_New(o)_t = Wagelevel(o)_{t-1} * years\ of\ working * 1\% \quad (4)$$

For the "middle" workers who started to work before 1996 and not retired before 1996, their pension payment includeds two parts: the first part is one percent of wage level of the labour catogory o in year t -1 times years of working; the second part is 0.3 percent of wage level of the labour catogory o in year t-1 times years of working before 1996.

$$Payment\_Middle(o)_t = Wagelevel(o)_{t-1} * years\ of\ working * 1\% + Wagelevel(o)_{t-1} * (1996 - YearStarted) * 0.3\% \quad (5)$$

Then the total payment in year t is the sum of payment paid to thsoe three catogories of the pensioners.

$$Payment1\_1_t = Payment\_Old_t + \sum_o Payment\_New(o)_t + \sum_o Payment\_Middle(o)_t \quad (6)$$

- ***Pillar two***

When we define the contribution to pillar two (individual account), we start with the individal contirbution.

$$Con\_PP2\_1(a,o)_t = Crate2\_1 * Wagelevel(o)_t \quad (7)$$

Where $Con\_PP2\_1(o)_t$ is pension contirbution made to pillar two per worker of labour catogory o and aged a in year t. $Crate2\_1$ is the contribution rate of pillar two, which is curretnly 8 percent of the wagelevel for all labour catogories. Euation 7 means that contirbution made to pillar two by individual worker at catogory o and aged a is simply eight percent of his/her salary.

The stock or accumulated contribution of each worker's individual account of labour category o at age a, at the start of year t is the stock accumulated in the last age, a-1 in year t-1, plus the interest earned and the contribution made at age a.

$$Stock\_PP2\_1(a,o)_t = Stock\_PP2\_1(a-1,o)_{t-1} + Stock\_PP2\_1(a-1,o)_{t-1} * IntRate + Con\_PP2\_1(a,o)_t \quad where\ a \in 20-57 \quad (8)$$

As mentioned earlier, the retirement age is 60 for male employees, 55 for female officers and 50 for female workers. In the CHINAGEM model, we do not have gender disaggregation, so

we assume that the average retirement age is 58 in 2012[10]. We assume that the average retirement age of the labour force is 58 from 2012 and onwards if the Chinese government keeps its current retirement policy. In equation 8, we calculate per worker's pension stock accumulated in pillar two at age a, where age a ranges from 20 to 57.

In equation 8, $Stock\_PP2\_1(a,o)_t$ is the pension stock of pillar two per worker of category o at age a, at the beginning of year t. The pension stock per worker after he/she has retired is calculated using following equation:

$$Stock\_PP2\_1(a,o)_t = Stock\_PP2\_1(a-1,o)_{t-1} * （1 + IntRate） + Payment\_PP2\_1(a,o)_t \quad where\ 58 \leq a \leq 100 \tag{9}$$

Equation 9 shows that an eligible workers' pension stock at the start of year t after he/she has retired equals his/her pension stock in the previous age in year t-1 plus the interest earned, then deduct the pension he/she received in year t. Where $Payment\_PP2\_1(a,o)$ is the pension received by the eligible worker of labour category o. $Payment\_PP2\_1(a,o)$ is calculated in equation 12.

The total pension stock of pillar two for the working age workers (age 20-57) is calculated as follow

$$Stock\_AG2\_1(a,o)_t = Stock\_PP2\_1(a,o)_t * EMPERSON(a,o)_t * COVERAGE(o)_t * P\_ACON\_P2\_1_t \quad \text{where a} \in 20-57 \tag{10}$$

Where $Stock\_AG2\_1(a,o)_t$ is the aggregated pension stock of labour category o at age a in year t. $P_ACON_P2_1_t$is the compliance rate of the pillar 2, scheme 1 in yeart t. Equation 10 says that total pension stock of pillar two for the working age workers of labour catogory o at age a in year t is per person pension stock of labour catogory o at age a in year t times the total number of employed persons of caogory o at age a in year t indexed by the coverage rate of category o and the compliance rate in year t.

For the retired wokers (aged 58 and older), the total pension stock of pillar 2 is

$$Stock\_AG2\_1(a,o)_t = Stock\_PP2\_1(a,o)_t * PopRetire(a,o)_t * COVERAGE(o)_t * P\_ACON\_P2\_1_t \quad \text{where } 58 \leq a \leq 100 \tag{11}$$

Where $PopRetire(a,o)_t$ is the eligible retired workers of category o at age a in year t. The aggregated pension stock of labour category o at age a in year t is per worker's pension stock of category o at age a in year t times the number of retired workers of category o at age a in year t indexed by the coverage of pension scheme and compliance rate of pension scheme in year t.

The annual pension payment of each eligible retired workers received from pillar two or their individual account is simply one fifteenth of their pension stock at age 58 (Equation 12). This

[10] We assume that men account for 60 percent of the total labour force and retire at 60 and women account for 40 percent and retire at 55, and hence the weighted average of retirement age for both genders is 58.

means that the government assumes that the remaining life expectancy upon retirement is 15 years. If the eligible worker is still alive after fifteen years of their retirement, then the government will continue to pay his/her pillar two pension even though his/her individual account has already become empty.

$$Payment2\_1\ (o)_t = Stock\_PP2\_1("58", o)_t/15 \quad (12)$$

Where $Payment2\_1\ (o)_t$ is the annual payment an eligible worker of category o received from his/her individual account. $Stock\_PP2\_1("58", o)_t$ is the pension stock a worker of category o has accumulated when he reaches his retirement age 58.

2.2.2.2 Basic Pension for Urban and Rural Residents – Scheme 2

Under China's current pension system, all the residents aged 20 and over should participate either Basic Pension for Urban Employees (scheme 1) or Basic Pension for Urban and Rural Residents (scheme 2). If a resident is not eligible for participating in Scheme 1, then he/she should contribute to Scheme 2.

- ***Contribution to the scheme***

The pension fund for Scheme 2 is financed by three sources: 1) government subsidies; 2) individual contributions and interests earned, and 3) collective subsidies. Among these three sources, the subsidies from the central and local governments have been the predominant one. As we mentioned in section one, Scheme 2 has two pillars as well - pillar one (social pool) financed by the government, and pillar two financed by the individual contributions. Since individual contributions have been relatively small[11], we thus ignore pillar two in the model. The total contribution to this scheme is calculated as follows:

$$ContributionAG\_2A(o)_t = Con\_PP\_2_t * Persons\_2\ (o)_t$$
$$where\ o\ belongs\ to\ USE,UUSE\ and\ RUE \quad (13)$$

$$Persons_{2(o)_t} = \left(1 - Coverage(o)\right) * \left(\sum\nolimits_a Emperson(a, o)\right)_t$$
$$where\ a \in (20 - 57\ ) \quad (14)$$

Equation 13 says that for the labour category of USE, UUSE and RUE workers, their contribution to pension fund, $ContributionAG\_2A$ in year t equals contribution paid per person in year t times the total number of workers in each category who participate in the scheme in year t, $Persons\_2(o)$. Equation 14 shows that $Persons\_2(o)$ in year t equals the employed persons summed by age who do not participate in the Basic Pension for Urban Employees. As we displayed in Table 2, the coverage rate of scheme 1 for USE, UUSE and RUE workers is 100 percent, 80 percent and 25 percent, respectively. Then the coverage rate for scheme 2 for USE, UUSE and RUE workers would be zero, 20 percent and 75 percent, respectively.

[11] The average annual contribution to individual accounts per PURR participant was ¥169.78 in 2012, and ¥178.51 in 2013 (Zheng, 2017). Most participants in western and middle provinces contributed to their individual accounts only ¥100 per annum.

For the workers who belongs to the rest of labour category and residents listed in Table 2, their contribution to the pension fund in year t equals contribution paid per person Con_PP_2 in year t times total number of persons in each labour category in year t, $Persons\_2(o)$ and then adjusts using the compliance rate P_ACON_P2 in year t. Here we assume that per person's contribution to the fund is the same for all the labour categories.

$$ContributionAG\_2B(o)_t = Con\_PP\_2_t * Persons\_2\ (o)_t * P\_ACON\_P2_t \quad (15)$$

Where o belongs to the labour category AG, RNAG, UU, RAGU, RUU and REST.
The stock of the pension fund is defined as

$$Stock\ \_2_t\ = Stock\ \_2_{t-1}\,(1 + IntRate) + \sum_o ContributionAG\_2(o)_t\ +\ Goverment\_2_t - PaymentAG\_2_t \quad (16)$$

Equation 16 suggests that the stock of the pension fund in year t is the stock of last year plus the interest earned plus the sum of contribution made in year t by all labour categories and the government subsidy in year t, $PaymentAG\_2_t$, then subtract the payment paid to the eligible residents in year t, $Payment\_2_t$.

- ***Pension benefits of the scheme***

The eligible residents will receive their pension benefits from the scheme after they reach the retirement age which in average is 60 years old. The pension benefit is defined as

$$PaymentAG\_2_t = PaymentPP\_2_t * PersonsPay\_2_t \quad (17)$$

Where $PaymentPP\_2_t$ is the pension payment per person from the scheme in year t, which is decided by the government. According to the Yearbook of China Social Security, average pension benefit per annum was ¥880 in 2012 and ¥1408 in 2016. We assume that pension benefit will increase at the rate of GDP growth from 2017 and onwards in the baseline scenario. $PersonsPay\_2_t$ is the total number of eligible residents who will receive pension payment from this scheme in year t. It is defined as

$$PersonsPay\_2_t = \{PopRetire_t - \sum_o PopRetire(o)_t\} * EliRate_t$$
where o belongs to USE,UUSE and RUE (18)

The total number of residents who are eligible to get the pension payment from Scheme 2 in year t is the total retired population in year t subtracts the persons who get the pension payment from scheme one, then adjusts using the eligible rate in year t. The eligible rate is calibrated using the historical data from 2012 to 2016. From 2017 and onwards, we assume that the compliance rate remains at its 2016 level.

2.2.3 Government account

In China, central and local governments provide subsidies to both PUE and PURR. According to the statistical data, pillar one- the social pool of scheme 1 has been running deficit for years (Zhao, 2015). With the expected rapid ageing, we would like to know if the Chinese government maintains the current pension system, how much deficit of social pool will accumulate. If the government chooses to finance the deficit how much the government general budget deficit will increase to and what the impact of the huge deficit on the macro economy?

In order to answer these questions, we introduce the government account into the CHINAGEM model.

As we know that government general budget balance is defined as general government budget revenue subtracts the general government budget expenditure. We will first discuss the general government budget revenue.

- **General government budget revenue**

In China, general government budget revenue mainly comes from two sources: tax revenue and non-tax revenue. The tax revenue includes 21 different tax revenues. In this study, we aggregate the 21 different tax revenues into three broad groups: (1) income tax revenue which includes corporate income tax and personal income tax revenues; (2) tariff revenue and (3) other tax revenues including the rest of 18 tax revenues. Based on 2017 China Statistical Yearbook, we find out that on average the above three tax revenues and non-tax revenues accounted for respectively 4.6 percent, 0.4 percent, 12.3 percent and 3.2 percent of GDP during 2012- 2016. In our baseline scenario, we assume that these shares remain at these levels during 2017-2100.

- **General government budget expenditure**

In China, general government budget expenditure mainly includes 23 items. In this study, except the item of "expenditure for social safety net and employment effort", we aggregate the 22 items into the following broad groups: (1) Expenditure for general public service; (2) Expenditure for education; (3) Expenditure for medical and health care and family planning; (4) Expenditure for other services. For the item of "expenditure for social safety net and employment effort", we further disaggregate it into four sub-items: (5.1) Expenditure for PUE; (5.2) Expenditure for PURR; (5.3) Expenditure for health care insurance and (5.4) Expenditure for other insurances. Based on 2017 China Statistical Yearbook, we calculate the shares of above expenditure items in GDP during 2012-2016. We find that the average shares of the first four expenditure items in GDP during 2012-2016 are 5.9 percent, 3.5 percent, 1.8 percent and 9.7 percent, respectively. The expenditure on PUE only accounted for 0.5 percent of GDP from 2012 to 2014 and it increased to 0.6 percent in 2015 and further to 0.8 percent in 2016. We assume that in our baseline scenario during 2017-2100, the budgetary expenditure on PUE as share of GDP will remain at its 2017 level of 0.8 percent. For the budgetary expenditure on PURR, it only accounted for 0.2 percent of GDP during 2012-2016. In our baseline scenario from 2017 to 2100, we assume that this share will remain at its 2016 level of 0.2 percent. For the budgetary expenditure on health care insurance and other insurance programs, we assume that the share of expenditure on health care insurance and other insurances in GDP will remain its 2016 level of 1.62 percent in our baseline scenario from 2017 to 2100.

- **General government budget balance**

Based on the 2017 China Statistical Yearbook, China's general government budget has run deficit since 2012. The amount of deficit accounted for 1.4 percent of GDP in 2012. It increased to 2.4 percent in 2013 and 2.5 percent in 2014, further jumped to 4.4 percent in 2015 and then

dropped back to 3.3 percent in 2016. Even though the government general budget balance has been in deficit, its size has been controlled under 5 percent of GDP.

3 Development of Baseline scenario and simulation results

To analyse the economic effects of later retirement policy, we first develop a baseline scenario - a business as usual without introducing any policy changes[12]. Then we conduct a policy simulation, an alternative forecast with the change at the retirement age. The effects of the policy change are measured by deviations of variables in the alternative forecast from their baseline levels.

3.1 Macro variables in the baseline scenario

To develop the baseline scenario, using the data from China Statistical Yearbooks and World Bank Development Indicators database, we first update the model's database to 2016. Then for the forecast period 2017 to 2100 we assume that the growth pattern of the Chinese economy will follow its historical trend but at progressively lower rates. For example, while the annual growth rate of total factor productivity will decline from 4.17 percent in 2017 to 3.8 percent in 2020, and further drop to 3.49 percent in 2030, 3.3 percent in 2050, 2.65 percent in 2080 and 1.78 percent in 2100 (Table 3).

Table 3: Summary of baseline calibration*

	2020	2030	2040	2050	2080	2100
Exogenously specified variables						
Annual growth rate (%)						
Investment	5.84	4.60	3.45	2.46	2.06	1.8
Export	7.49	6.31	5.28	4.46	3.4	2.7
Total factor productivity	3.8	3.49	3.36	3.3	2.65	1.78
Labour force	-0.34	-0.62	-1.10	-1.43	-1.29	-0.92
Endogenously solved variables						
Annual growth rate (%)						
Capital stock	5.51	5.09	4.19	3.16	2.07	1.76
Real GDP	6.70	5.77	4.81	4.04	2.81	2.0
Real wage rate	6.85	6.22	5.80	5.40	4.04	2.86
Real household consumption	7.29	6.31	5.24	4.59	2.81	1.90
Import	7.03	6.57	6.40	5.29	3.82	3.0

Source: Baseline simulation results. ***** Only selected years results are displayed in this table.

[12] For more detail about how the business-as-usual scenario is developed for the CHINAGEM model, please see Mai et. al (2006).

The growth rates of rural migrant workers and other labour categories in the baseline scenario are endogenized and determined by the exogenous macro variables such as investment, export, and GDP, and the growth rate of total labour force (refer to Table 3 for the baseline results). The growth rate of the exogenous variable such as total labour force is calculated based on the growth rate of working-age population and the aggregate labour force participation rate to be discussed in section 4 (please refer to Figure 7). In the baseline scenario, we assume that the cohort labour force participation rates will remain at their 2010 levels until 2100. The growth rate of working-age population is from the medium variant of population projection conducted by Zuo et. al. (2020).

Table 3 shows that China will experience persistent labour force declining in the future. The labour force will decline at a rate of 0.34 percent in 2020 and further down to 0.62 percent in 2030. It will further drop at a rate of 1.43 in the middle of the century and at 0.92 percent at the end of the century. The baseline simulation shows that with the continuously declining labour force, China has to rely on the capital stock growth and total factor productivity improvement to sustain its economic growth.

3.2 Variables and data related to the pension module

Table 4 shows the details of pension account of Scheme 1 (total amount of pillar one and pillar two) from 2012 to 2016. The retired pensioners of Scheme 1 have increase from 74.46 million in 2012 to more than 100 million in 2016. We can see that from 2012 to 2016, the pension fund is in surplus and the pension stock has been increased (accumulated surplus) from ¥2394 billion in 2012 to ¥3901 billion in 2016. However, as reported by Zheng, 2012, the stock of pension fund of pillar one (social pool) in14 provinces has ran out in around 2011 and it has been in deficit since then. The government has to use the money in pillar two (individual accounts) to pay the pension benefits for the retired workers. In order to accurately forecast the accumulation of pension fund from 2017 to 2050, we have to split Table 4 and get the pension accounts for pillar one and pillar two, respectively. Please refer to Annex A for the details of how we split the data. The pension accounts for pillar one and pillar two from 2012 to 2016 are displayed in Table A1 and Table A2, respectively. Since pension fund of pillar one has run out in 2012, so the increase of pension stock shown in column 8, Table 4 is actually from pillar two.

Table A2 displays the pension account of pillar one, Scheme 1 from 2012 to 2016. We assume that the stock of pension fund of pillar one is 0 in 2012. Since the annual payment to pensioners (expense) in pillar one (column 5, Table A2) is larger than the annual revenue (contribution plus the government subsidy and interest and other income, the sum of column 1, 2 and 3, Table A2) in pillar one, the annual surplus is negative (Column 6, Table A2). As a result, the stock of pension fund is negative since 2013 (Column 7, Table A2). Table A2 displays the pension account of pillar one, Scheme 1 from 2012 to 2016. We assume that the stock of pension fund of pillar one is 0 in 2012. Since the annual payment to pensioners (expense) in pillar one (column 5, Table A2) is larger than the annual revenue (contribution plus the government subsidy and interest and other income, the sum of column 1, 2 and 3, Table A2) in

pillar one, the annual surplus is negative (Column 6, Table A2). As a result, the stock of pension fund is negative since 2013 (Column 7, Table A2).

Table 4: Pension account of Basic Pension for Urban Employees -PUE (¥ billion)

	Pensioners (1)	Contribution (2)	Government Subsidy (3)	Investment returns and other (4)=(5)-(2)-(3)	Total Revenue (5)	Total Expenditure (6)	Annual Surplus (7)=(6)-(5)	Accumulated Surplus (8)
2012	74.46	1646.7	264.8	88.6	2000.1	1556.2	443.9	2394.1
2013	80.41	1863.4	301.9	90.3	2268	1847	408.62	2838.0
2014	85.93	2033.4	359.4	118.0	2531	2175.5	334.92	3246.6
2015	91.42	2301.6	471.6	127.93	2934.1	2581.3	319.83	3581.5
2016	101.03	2676.8	651.1	129.74	3505.8	3185.4	272.245	3901.4

Source: Bulletin on the Development of Human Resources and Social Security in China, 2012, 21013 and 2015; Annual Report on the Development of Chinese Social Insurance, 2014 and 2016.

Table A3 displays the pension account of pillar two, Scheme 1. With the positive annual surplus, the stock of pension fund increased from 2394.1 billion in 2012 to 5436.3 billion in 2016. Given the amount of contribution in Column 1, Table A2, using the equation one, we calibrated the compliance rate of pillar one from 2012 to 2016. Our calculation shows that the compliance rate was only 42.1 percent in 2012 and 42.4 percent in 2013, and it increased to 45.5 percent in 2016. This calibrated number is consistent with some scholars' observation in China. According to the current pension policy, if a worker has continuously contributed to pillar one, Scheme 1 for minimum 15 years, he/she will be eligible to get pension from social pool after he/she retires. This policy obviously discourage workers to continue to contribute to the social pool (pillar one) after they have completed their "15 years" compulsory contribution. In order to encourage workers to continue to contribute to the scheme, government should consider to changing this policy (Xue and Zhang, 2017). In the forecast period of 2017 to 2050, we assume that the compliance rate of pillar one, Scheme 1 will remain at the 2016's level, 45.5 percent.

Based on the contribution data in column 1, Table A3, using the equation 9 in Section 2, we calibrate the actual participating rate of pillar two, Scheme 1. The calculation shows that the actual participating rate is only 38.6 percent in 2012, 40.5 percent in 2013 and it increased to 44.7 percent in 2016. We assume that the actual participating rate of pillar two, Scheme 1 will remain at the 2016's level, 44.7 percent in the forecast period 2017 to 2050.

Table 5 shows the details of pension account of PURR (Scheme 2). Similarly, based on the contribution data in column 2, Table 5, using the equation 12 in section 2, we calibrate the compliance rare (actual participating rate) of Scheme 2. The calculation results are displayed in column 8, Table A3. In the forecast period of 2017 to 2050, we assume that the participating rate of Scheme remains at the 2016 level, 61.3 percent.

Table 5: Revenues and Expenditures of PURR, 2012-16 (¥ billion)

	Pensioners (million) (1)	Contribution (2)	Government Subsidy (3)	Interest income and other (4)=(5)-(2)-(3)	Total Revenue (5)	Total Expenditure (6)	Annual Surplus (7)=(6)-(5)	Accumulated Surplus (8)
2012	130.75	59.4	112.65	10.85	182.9	115	67.9	230.2
2013	137.68	63.6	137.03	4.57	205.2	134.8	70.4	300.6
2014	143.13	66.6	149.75	14.65	231	157.1	73.9	384.5
2015	148.00	70	205.33	10.17	285.5	211.7	73.8	459.2
2016	152.70	73.2	207.31	12.79	293.3	215.1	78.2	538.5

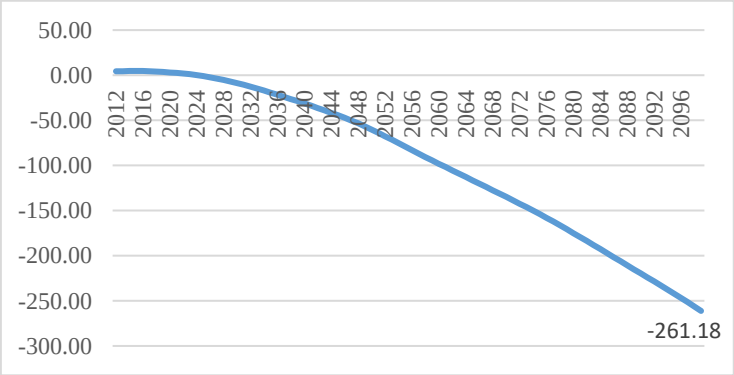
Source: Bulletin on the development of human resources and social security in China, 2012, 21013 and 2015; Annual Report on the Development of Chinese Social Insurance, 2014 and 2016.

To simulate the change of pension fund in the baseline scenario for the period of 2017 to 2100, we assume that the Chinese government will keep its current pension system and the current contribution rates for each scheme. To simulate the impact of pension payment on government general budget balance, we also assume that the shares of general government revenue over the GDP and the shares of general government expenditure over the GDP keeps their historical pattern over the forecast period.

3.3 The impact of population ageing on pension fund and government budget balance

As we discussed in last section, the stock of pillar one is negative and the Chinese government uses the money in pillar two to pay the retired workers their pillar one pensions. Meanwhile the eligible retired workers also receive their pension from their personal account-pillar two. If the current pension system remains in China, then the stock of pension fund will run out of surplus and turn to negative in 2025 and the deficit will accumulate to nearly ¥10,000 trillion in 2099, which accounts for 261 percent of GDP in 2099 (Figure 2). The main reason of the pension fund becomes negative is the accumulated deficit of pillar one - the annual payment to retired workers is much larger than the annual revenue (the sum of contribution, government subsidy, interests and other income).

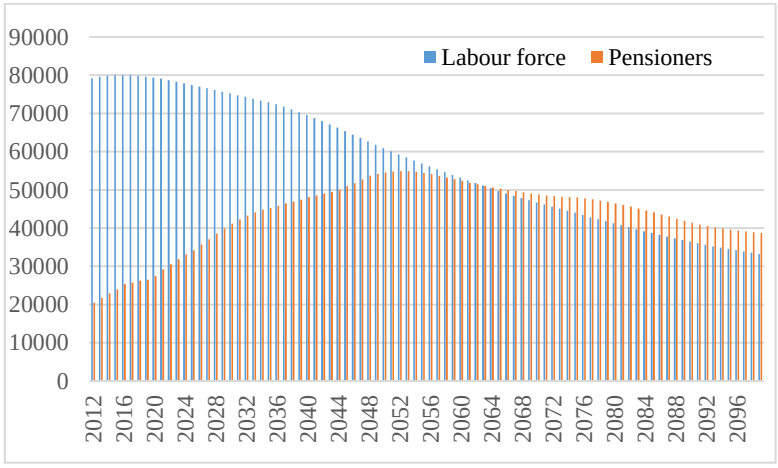
Figure 2: Stock of pension fund PUE as share of GDP, 2012 to 2099 (%)



Source: Baseline simulation result

With the rapid population ageing, the gap between the revenue and pension payment become bigger because there is less labour force to contribute to the pension scheme (the negative growth of labour force) and more pensioners to receive pension payment (the rapid growth of old population). From Figure 3 we can see that in the middle of the century, the labour force will decline to 609 million, which is a 23 percent drop from its 2012 number (792 million). By the end of the century, the labour force will further decline to 332 million, which is less than half of its 2012 number. Meanwhile, the retired workers who are eligible for receiving pension from Schemes 1 and 2 will increase to 545 million in the middle of the century, which is a 166 percent increase from its 2012 number. The retired workers will surpass the labour force at 2064. By the end of the century, there will be 55 million more retired workers than the labour force.

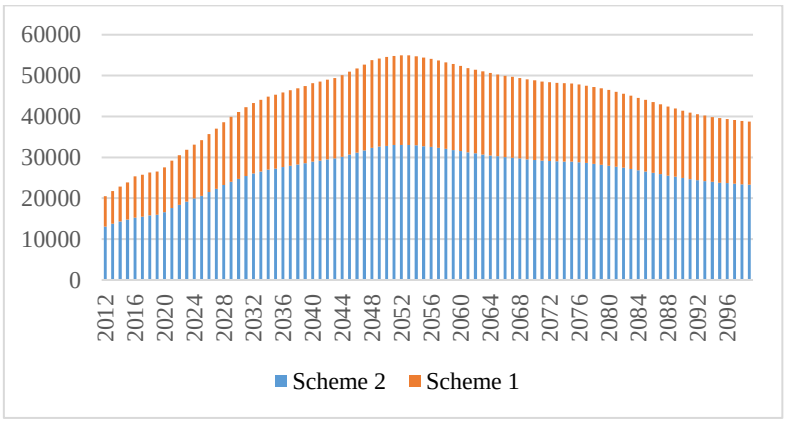
Figure 3: Declining labour force and increasing pensioners, 2012 to 2099 (10,000 persons)



Source: Population projection and baseline simulation result

We also notice that among 545 million pensioners, there is 217.3 million pensioners who receive pension from Scheme 1 (Figure 4).

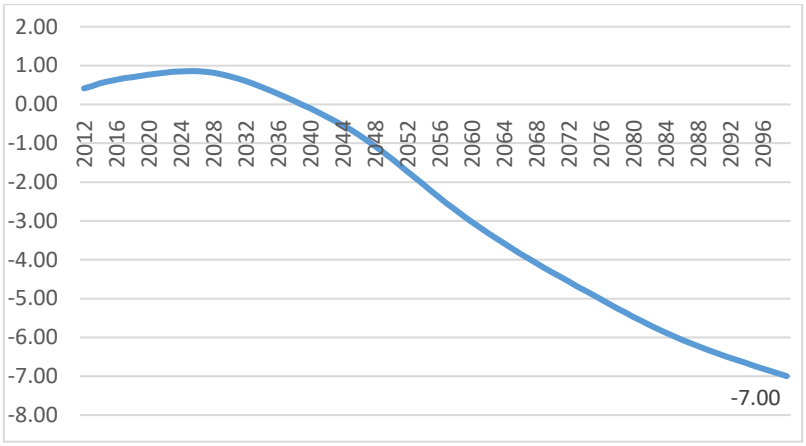
Figure 4: Increasing pensioners of two pension schemes, 2012 to 2099 (10,000 persons)



Source: Population projection and baseline simulation results

Figure 6 shows the stock of pension fund PURR –Scheme 2 as share of GDP. The pension payment to each pensioner in Scheme 2 is small (only ¥880 in 2012 and it increased to ¥1409 in 2016). Even though we assume that its payment will increase at the rate of real GDP annually, the total pension payment compared with the Scheme 1 is still relatively small. As we discussed in section 2, this pension fund mainly rely on the government subsidies. We assume that the government will subsidy the difference between the pension payment and the contribution. That means if the pension payment in year t is ¥20 million and the contribution in year t is only ¥5 million then the government will subsidize ¥15 million. Meanwhile we also assume that the share of the government subsidies to Scheme 2 over the GDP will be fixed at 0.22 percent of GDP during the simulation period of 2017 to 2100. With the increase of retired population as a result of the rapid ageing, the government subsidies to Scheme 2 has to increase every year. However, the subsidies cannot be more than 0.22 percent of GDP. That is why we notice that the stock of pension fund of scheme 2 become negative from year 2037 and the debt of pension fund continue to increase. The debts will accumulate to ¥8.8 trillion in 2050 and further increase to ¥268 trillion in 2099, which accounts for 7 percent of GDP in 2099 (Figure 5).

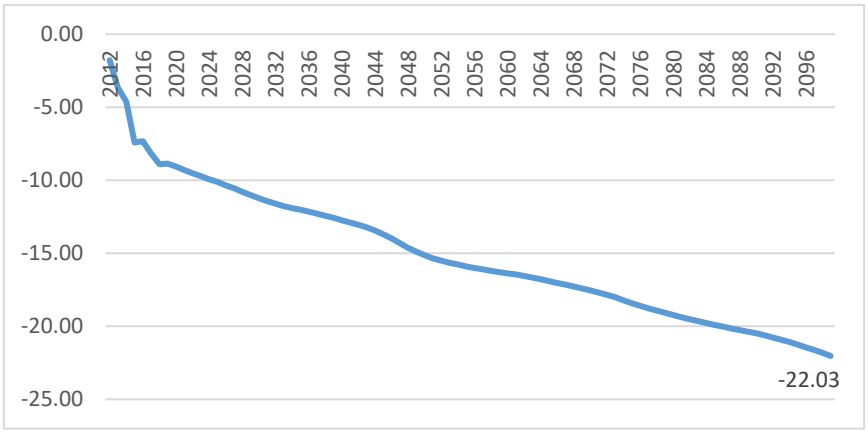
Figure 5: Stock of PURR pension fund as share of GDP (%), 2012 to 2099



Source: baseline simulation results

If the government chooses to pay the debts of the pension schemes by increasing the government expenditure on the pension insurance, then this will put high pressure on general government budget balance. As we discussed in Section 2.3, the general government budget balance has been in deficit since 2012, however the share of the deficit over GDP has been controlled under 5 percent. With the rapid accumulation of debts of pension fund, the general government budget deficit will increase very fast. If the government chooses to pay the pension debts and its resulted interests every year, then the share of general government budget deficit over GDP will increase to 15 percent in 2050 (Figure 6), and further increase to 22 percent by the end of the century, which implies that the economy cannot sustain under such big deficit. The Chinese government has to find ways to reform its current pension system and sustain its economic growth. In this study, we will investigate the impact of increasing retirement age on the economy and pension system. In other words, we would like to know whether increasing the retirement age will help to reduce the pressure on the pension fund meanwhile stimulate the economic growth given the rapid population-aging problem as a backdrop.

Figure 6: General government budget deficit as share of GDP (%) 2012 to 2099



Source: baseline simulation results

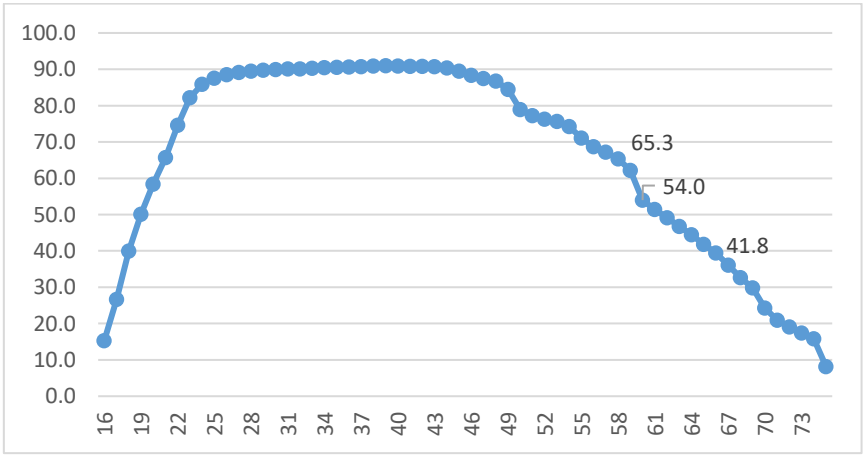
4 The effects of later retirement policy

This section contains an analysis of the economic effects of raising the retirement age.

4.1 Retirement age and labour force participation rate

In the baseline scenario we assume that age specific labour force participation rates, therefore aggregate labour force participate rate will remain their 2010 level over the simulation period of 2017 to 2050. The labour force participation rate (LFPR) for the population aged 50 and over has a very close relationship with the official retirement age and pension policy (Peng and Mai, 2013).

Figure 7: Age specific labour force participation rates in 2010 (%)



Source: Authors' calculated based on the Sixth Census data.

Figure 7 shows that during 2005-2010, the labour force participation rate was around 90 percent for the population aged 28 to 48 (Ma, Lv and Ye, 2010). It declined to below 80 percent for the population aged 49. It further dropped to 65.3 percent for the population aged 58 and 54 percent for the population aged 60. The labour force participation rate for population aged 65 was only

41.8 percent in 2010. The main reason for low labour force participation rates for the population aged 55 and over is China's official rather early retirement age. As we discussed in Section one that currently the retirement age is 60 for male employees, 55 for female officials and 50 for female workers in China. Compared with other countries China's retirement age is very low. For most of developed countries the retirement age is 65 for both men and women. With the expected decline of the working age population in China, an increase in the retirement age will be an effective way to increase the labour force participation rate. A gradual increase in the retirement age will not only help to slow down the reduction of the effective workforce but also lower the expected increase in labour costs. It will also help to alleviate the pressure on the pension fund which has been reported in deficit in many provinces (Zheng, 2016).

In the policy scenario, we assume that the Chinese government will gradually increase both male and female workers' retirement age from 2020 onwards. We assume that in 2020, the average retirement age will increase to 59 years old. In 2022, it will further increase by one year to 60 years old. Following this pattern, it will increase by one year for every two years until 65 years old in 2032. It then remains at 65 years old from 2033 to 2100. The increase of retirement age will result in an increase in the LFPR. To our knowledge, there is no research on the extent to which a one-year increase in the retirement age will increase the LFPR of the corresponding age group. Based on the corresponding age groups' LFPRs of Japan, Korea, G7 countries and OECD countries in 2016[13], we assume that the LFPRs for population aged 54 will increase from 74.21 percent to 75 percent in 2020 and remain at this level till the end of the century. The assumption for the increases of the LFPA for population aged 55 to 65 please refer to Table A3 in Annex 2.

Based on the above assumptions, we calculate the corresponding shocks to the LFPRs of these age groups in the policy scenarios. Meanwhile we shock the retirement age. Therefore, the new retirement age in the policy scenario becomes 59 in 2020, 60 in 2022, 61 in 2024, 62 in 2026, 63 in 2028, 64 in 2030 and 65 in 2032. These shocks mean that comparing with the baseline scenario, in the policy scenario the labour force will be larger from 2020 and the contribution to the pension fund will increase. Meanwhile the size of retired population will be smaller.

4.2 The effects of later retirement policy on macro economy

4.2.1 The effects on real GDP

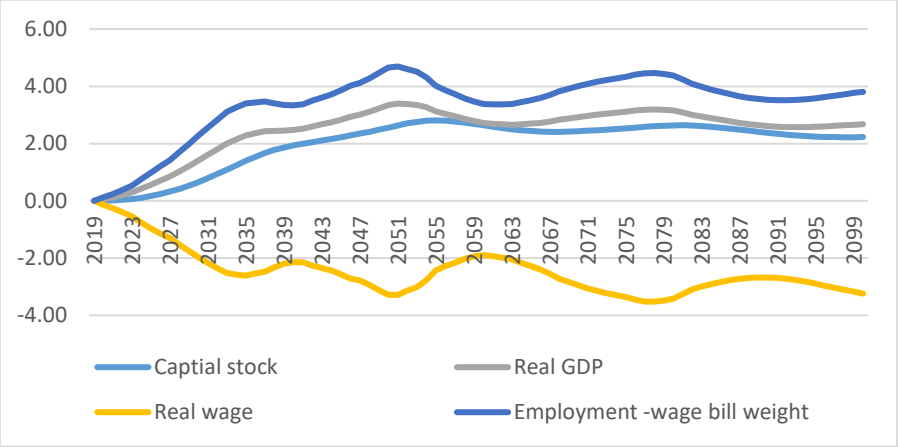
The increase of retirement age will increase labour force and boost China's economy. Figure 8 shows that by the end of simulation period real GDP will be 2.7 percent higher than in the baseline scenario.

There are two reasons for the higher real GDP. First, the increase in the labour supply as a result of the extension of the retirement age contributes to the growth of real GDP. Figure 8

[13] The labour force participation rates (LFPR) for age group of 55 to 64 was 73.7 per cent for Japan, 68 per cent for Korea and 59.6 per cent for OECD countries in 2016. For Japan, the LFPR for age group 55-59 was 83 per cent and 68.1 per cent for age group 60-64 per cent and 45.3 per cent for age group 64-69 in 2017.

shows that by the end of simulation period, the effective labour input (employment indexed by wage bill weight) will be 3.8 percent higher than in the baseline scenario.

Figure 8: The effects of later retirement policy -GDP and other macro variables - Cumulative deviation from baseline scenario (%)



Source: Policy simulation results

Secondly, a growing capital stock contributes to higher GDP growth. In the long run the total capital stock will be 2.2 percent higher than in the baseline scenario (Figure 8). The long-run increase in the capital stock relative to baseline is due to the increase in employment. We notice that the deviation of the capital stock from baseline scenario is lower than that of labour input. The reason is that the increase in labour supply will reduce the growth rate of real wages. By the end of the simulation period, the real wage will be 3.2 percent lower than in the baseline scenario. The declining growth rate of real wages compared with the baseline scenario implies that labour is becoming cheaper and employers will have intention to substitute labour for capital, which will reduce the capital –labour ratio of the economy in the long run. The substitution between capital and labour will slow down the growth rate of the capital stock.

Figure 9: Growth rate of population aged 58-65 (%)

Source: Authors calculation from the medium variant population projection results

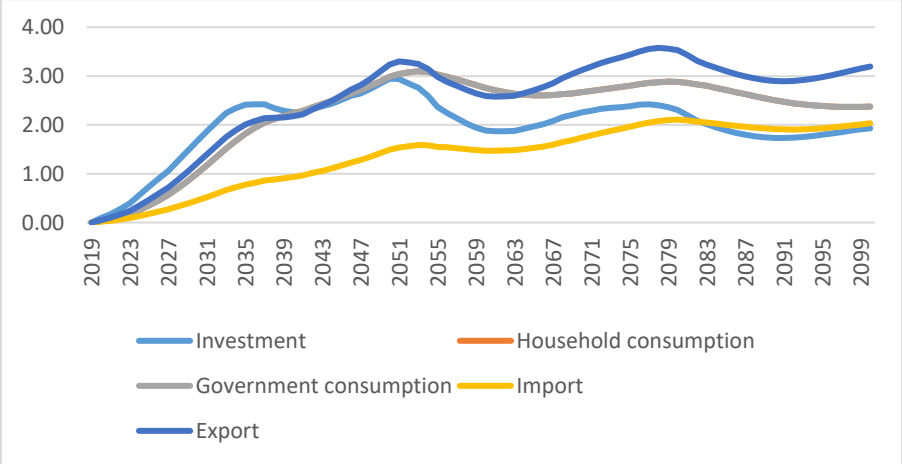
Please note the shapes of deviations of GDP and capital stock from baseline scenario are consistent with the growth of employment and labour supply aged 54 to 65 in the policy scenario. Since we increased the LFPRs of population aged 54 to 65 in the policy scenario, the increase of the labour force from these age group continues through the whole policy simulation period of 2020 to 2100 (Figure 9).

4.2.2 The effects on the expenditure side of GDP

Due to the increase in the capital stock, aggregate investment also increases relative to its baseline path (Figure 10).

In the long run the increase in labour supply stimulates the growth of China's exports. As Figure 10 shows, exports will be 3.2 percent higher than in the baseline scenario. The reason is that with the slower growth of the wage rates of workers, labour cost in export sectors, especially in manufacturing, is reduced. This further increases the competitiveness of Chinese exports in the world market. As a result Chinese exports expand. The expansion of exports implies more employment opportunities, which may further stimulate the development of export-oriented sectors in China.

Figure 10: The effects of later retirement on Expenditures side of GDP
- Cumulative deviation from baseline scenario (%)



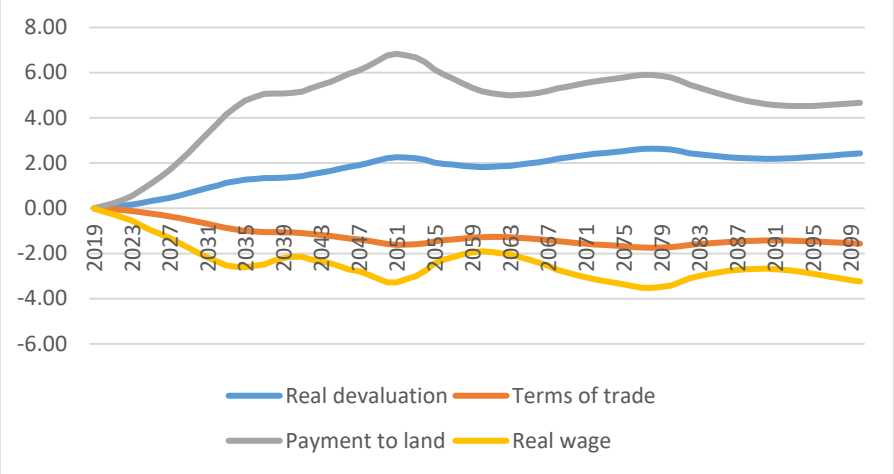
Source: Policy simulation results

The increased labour supply also improves households' living standards measured by real consumption. As Figure 10 shows, real household consumption will be 2.4 percent higher than in the baseline scenario. We also notice that consumption increases less than real GDP. The reasons include:

- Firstly, the constant expansion of exports requires a deterioration of the terms of trade, which will affect the gains from a given volume of trade adversely. As we just discussed the retirement age extension policy will increase China's export (Figure 10). The expansion of exports drives the terms of trade down because China is a "large country" in her export markets. The price of imports remains unaffected because we assume that China does not exert noticeable market power in her import markets. Figure 11 shows

by the end of the simulation period the terms of trade will be 1.6 percent lower compared with the baseline case.

Figure 11: The effects of later retirement on other macro variables:
-Cumulative deviation from baseline scenario (%)



Source: Policy simulation results

- Secondly, the higher labour force will reduce the per capita availability of the fixed factor (land). As labour supply increases with the result of increased retirement age, land becomes more scarce and expensive. Figure 11 illustrates that the payments to land will be 4.7 percent higher than in the baseline scenario. The dramatic increase in the price of land indicates the presence of diminishing returns to the extra labour and capital. This subdues the increase of income and consumption.

4.2.3 The effects on real wage

Figure 11 shows that the real wage rate will be 3.2 percent lower at the end of the simulation period compared to the baseline scenario. There are two main reasons for the reduction of real wage rate. First, the deterioration of the terms of trade together with the depreciation of the domestic currency (The expansion of exports requires a real devaluation of RMB relative to the exchange rate path of the baseline scenario. Figure 11 shows that the value of RMB is 2.4 percent lower than in the baseline case) reduces the real wage rate as the retirement age increases. Secondly, the increase of labour force reduces the relative availability of fixed resource, specifically land, and drives up its price as we discussed in the previous paragraph (Figure 11). The increasing scarcity of land is associated with an increase in the labour intensity of production which in turn reduces the productivity of labour and, thus, depresses the wage rage.

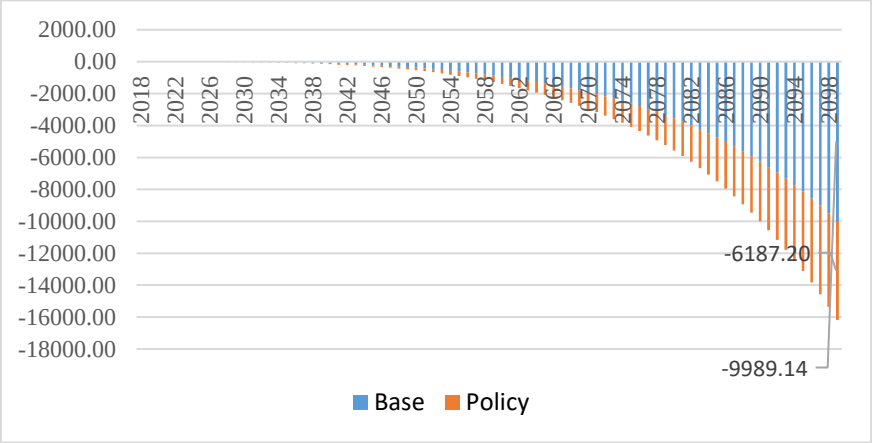
4.3 The effects of retirement age extension policy on pension fund and government budget balance

The increase of the retirement age will affect the pension fund and government budget balance dramatically.

4.3.1 The effects on the pension fund of Scheme 1

Figure 12 display the pension stock of Scheme 1 in baseline and policy scenarios.

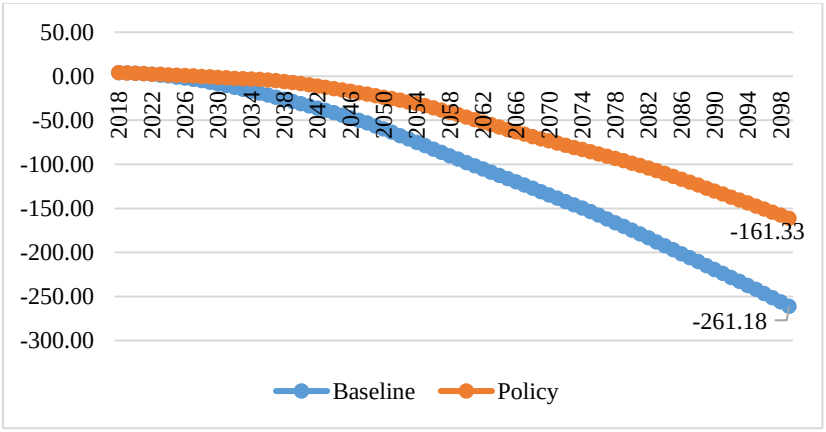
Figure 12: The effects of retirement age extension –Stocks of pension fund, Scheme 1, baseline and policy scenarios (¥ trillion)



Source: Baseline and policy simulation results

In the baseline scenario, the pension fund will run out of money and turn to negative in year 2025 while in the policy scenario, with the increase of the retirement age, the stock of pension fund will turn to negative in year 2028. By the end of the century, the accumulated debt of pension fund of Scheme 1 in the policy scenario will be Y6190 trillion which is more than 160 percent of GDP (Figure 13). Compared with the baseline scenario, the accumulated debts is 38 percent lower (Figures 12 and 13).

Figure 13: The effects of retirement age extension – share of stocks of pension fund over GDP, Scheme 1, baseline and policy scenarios (%)



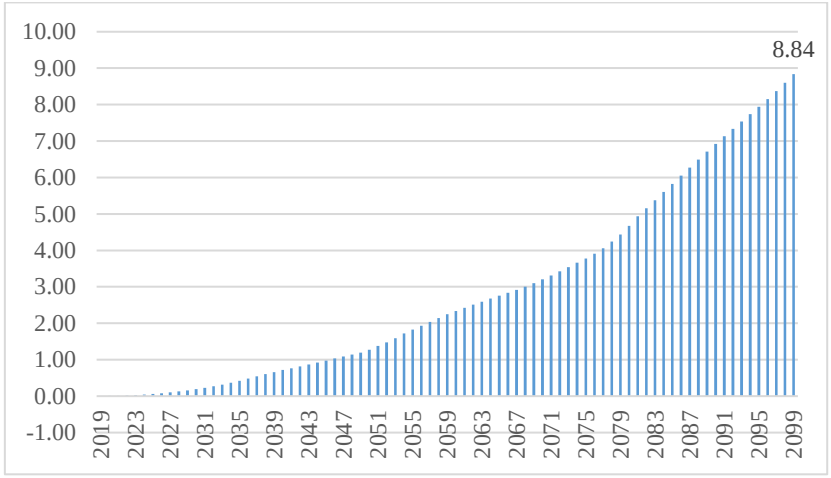
Source: Baseline and policy simulation results

The reasons for the reduction of the pension fund debt include:

- Firstly, increased contribution to the pension fund. The increased labour force as a result of the later retirement policy will increase the contribution to the pension fund. Figure

14 shows that by the end of the century, the accumulated contribution to the pension fund will be Y8.84 trillion higher than the baseline scenario.

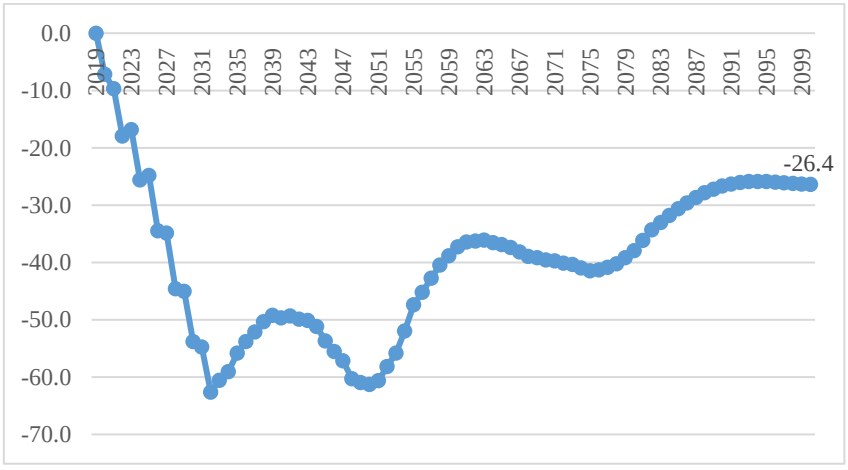
Figure 14: contribution to Scheme 1, cumulative deviation from the baseline (¥ trillion)



Source: policy simulation results

- Secondly, less expenditures from pension fund. The smaller size of the pensioners induced by the later retirement policy will reduce the total payment to the pensioners. Figure 15 shows that by the end of simulation period, the size of retired workers who receive the pension fund from Scheme 1 will be 26.4 million smaller in the policy scenario than in the baseline scenario.

Figure 15: The effects of later retirement on the size of the retirees, Scheme 1, - cumulative deviation from the baseline (million persons)

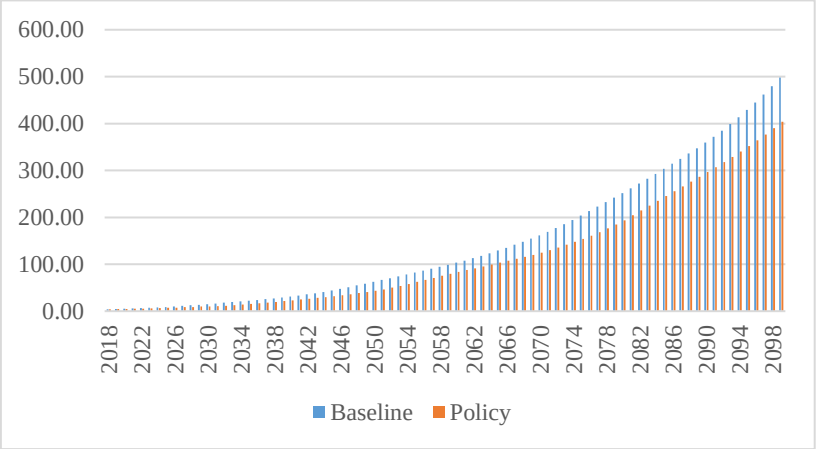


Source: policy simulation results

Figure 16 shows that the payment to the eligible retired workers is ¥5.01 trillion in the baseline while it is ¥4.66 trillion in the policy scenario in 2020. By the end of the

century, the pension payment is ¥498 trillion in the baseline scenario while it is ¥404 trillion in the policy scenario, which is a 19 percent decrease.

Figure 16: Payment to the retirees, Scheme 1, baseline and policy scenarios (¥ trillion)

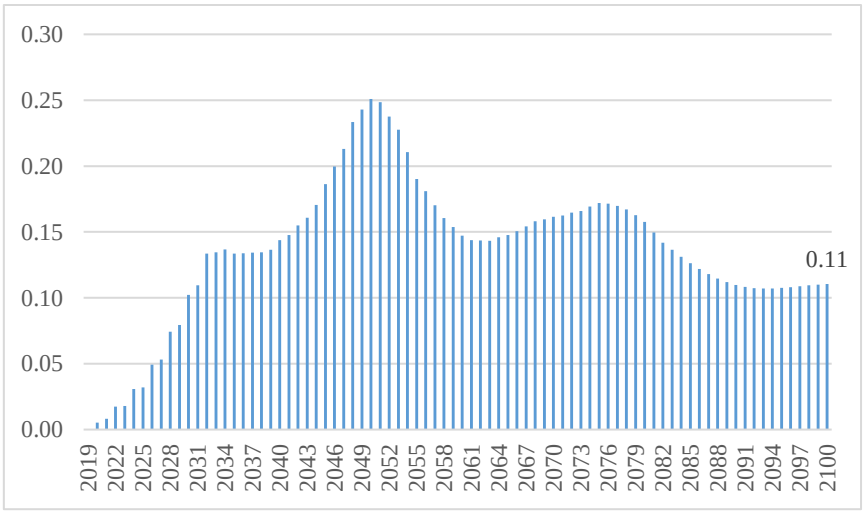


Source: Baseline and policy simulation results

4.3.2 The effects of later retirement policy on the pension fund of Scheme 2

The later retirement policy will reduce the debts of the pension fund, Scheme 2. At the end of this century the debts of the pension fund will be ¥1.2 trillion lower than the baseline scenario.

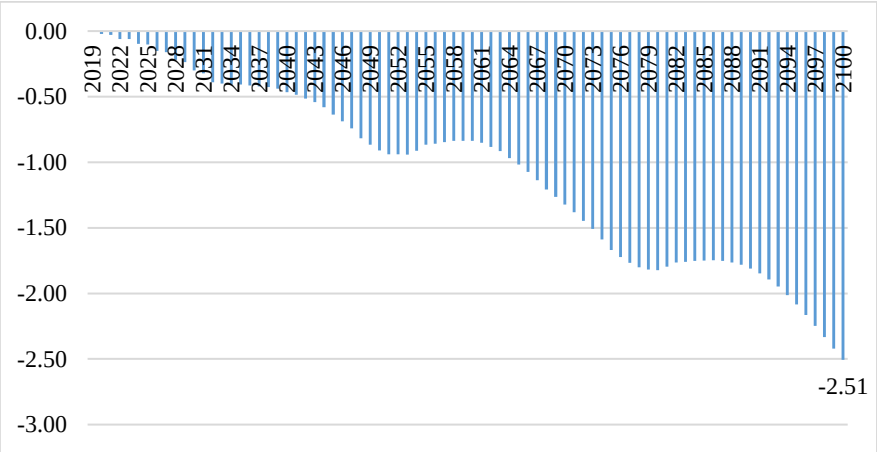
Figure 17: The effects of later retirement on contribution, Scheme 2 - cumulative deviation from the baseline (¥ trillion)



Source: Policy simulation results

The reasons are similar with the Scheme 1: (1) increased contribution to the pension fund. By the end of the simulation period, the contribution will be 0.11 trillion higher than the baseline (Figure 17); (2) reduced pension payment. By the end of the simulation period, the pension payment will be 2.5 trillion lower than the baseline scenario (Figure 18).

Figure 18: The effects of later retirement on pension payment, Scheme 2 - cumulative deviation from the baseline (¥ trillion)

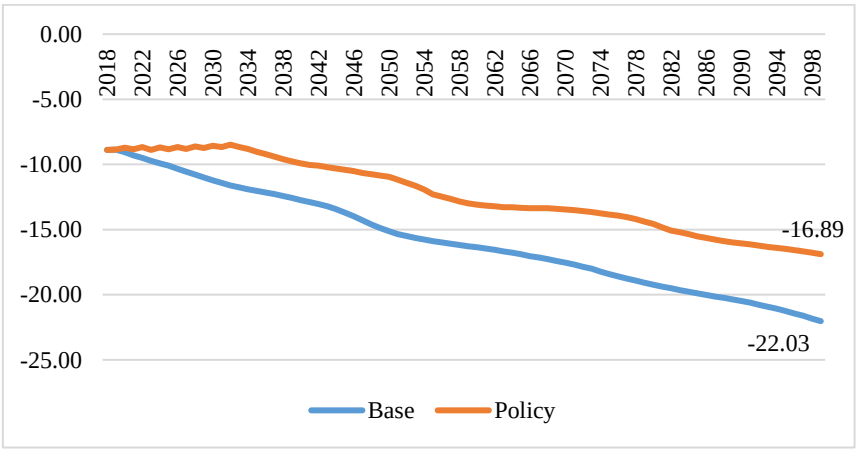


Source: Baseline and policy simulation results

4.3.3 The effects of later retirement on the general government budget balance

The decline of debts of both pension schemes with the implementation of the later retirement policy will help government budget balance. Figure 19 shows that general government budget deficit will reduce dramatically. By the end of simulation period, the general government budget deficit as share of GDP will drop from more than 22 percent (baseline scenario) to almost 17 percent, which is a 24 percent decline. The improvement of general government budget balance implies that there is less pressure on the increase of taxes or reduction of government spending and less crowding out effect on investment.

Figure 19: General government budget deficit as share of GDP (%), -baseline and policy scenarios



Source: Baseline and policy simulation results

5. Conclusions and policy implications

China is experiencing rapid population ageing. Using a dynamic computable general equilibrium (CGE) model of the Chinese economy, we project China's economic performance over the period of 2017 to 2100 under the background of rapid population age structure change.

The simulation exercise reveals that the rapid population ageing will exert high pressure on the current pension system and make the growth of the economy unsustainable:

- China will experience persistent labour force decline in the future. The labour force will decline at a rate of 0.33 percent in 2020 and further down to 1.32 in the middle of the century and at a rate of 0.92 at the end of the century.
- China has to rely on growth in capital stock and total factor productivity to sustain its economic growth.
- The rapid increase of the old population and decline in the labour force will drive the pension fund into deficit and the deficit will accumulate rapidly. In the middle of the century China's pension deficit will reach more than ¥520 trillion, which is equivalent around 50 percent of that year's GDP. It will further accumulate to almost ¥10,000 trillion which is equivalent 260 percent of GDP at the end of the century.
- The huge pension debt will put high pressure on China's general government budget balance. If the government choose to pay the debt annually, it will increase the government budget deficit. By the end of century, the general government deficit will account for more than 22 percent of GDP.

Thus, reform the current pension system and find ways to deal with the ageing problem become very urgent. Increasing the retirement age has been discussed among the scholars and the Chinese government as a way to mitigate the negative effects of ageing problem on pension system and macro economy. Applying a dynamic CGE modelling approach, we estimate the effect of raising the retirement age on China's macro economy and pension system over the period of 2020 to 2100. We find out that raising the retirement age will

- Boost China's economic growth by increasing employment and capital stock. By the end of simulation period, real GDP will be 2.7 percent higher than the baseline scenario;
- Improve household living standard measured by real household consumption. By the end of simulation period, real household consumption will be 2.4 percent higher than the baseline scenario;
- Improve the pension fund effectively. By the end of simulation period, the pension deficit will reduce from baseline's ¥10,000 trillion to ¥6190 trillion, which is 38 percent lower than the baseline scenario.
- Improve general government budget balance. The retirement age extension will bring the general government deficit back to around 17 percent of GDP.

As a summary, retirement age extension is a powerful policy. It will not only increase the labour force of the economy by increasing the labour force participation of the population, but also reduce the size of retired workers who receive pension by delaying them into the pool of pensioner. China's economy will benefit even more from this policy if the policy could be implemented soon.

Since the simulation results are very sensitive to the assumption of the increase of LFPRs of population aged 54 to 65 when the government increase the retirement age. We know that

increase the retirement age will have positive effect on the LFPRs of the age groups which are affected. However, how much the LFPRs will be increased and how many workers will choose to stay in the labour force after the policy becomes effective really depends on how the policy is designed. Carefully design the policy and implement it with caution will help the country gain the benefit of the policy.

We also notice that the effects of the policy will reach its highest point at around the middle of the century, and will diminish thereafter. There are several reasons for the diminishing effects of the policy. First, this is due to the slowdown in the growth of population aged 58-65 (Figure 9). Later retirement, to a large extent, allows those aged 58 to 65 become an increment to the labour force and employment. The slower growth of these cohorts in the second half of this century will surely dwindle such effects as compared with the baseline scenario. Secondly, the V shape of the change of the retirement workers. Figure 15 shows the cumulative deviation of the retirement workers in the policy scenario from the baseline case. We notice that the reduction of retired workers will reach its highest point at around the middle of the century. The retired workers will be around 61 percent lower than the baseline scenario in 2049. After 2049, even though the number of retired working is still lower than the baseline scenario, the reduction becomes smaller. By the end of the century, the retirement worker is only 26 percent lower than the baseline case. The effects of later retirement policy on macro economy and pension funds are the combined results of the above two factors. To sustain the effect of the policy, one feasible option is to further postpone the retirement age to 67 or even 70 after the middle of the century; this is the policy practice of some European countries nowadays.

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Annex 1: Data for the Basic Pension for Urban Employees (PUE) - Scheme 1

The data for the contribution to each pillar in scheme one is not available. However, we have data for contribution to each pillar for the enterprise pension fund. Since the enterprise pension fund accounts for around 90 percent of fund in the PUE or Scheme 1, so we use the shares of contribution to each pillar in the enterprise pension fund as the shares of each pillar for Scheme 1.

Table A1: Shares of pillars one and two in Scheme 1 (%)

	Contribution		Payment		Accumulated Surplus (8)	
	Pillar one	Pillar two	Pillar one	Pillar two	Pillar one	Pillar two
2012	62.0	38.0	95.86	4.14	0	100
2013	62.9	37.1	95.71	4.29	--	--
2014	63.3	36.7	95.61	4.39	--	--
2015	63.3	36.7	95.46	4.54	--	--
2016	63.3	36.7	95.30	4.70	--	--

Source: The Annual Report of Chinese Social Insurance Development, 2014, 2015 and 2016, Social Insurance Management Centre, Ministry of Human Resources and Social Security of the PRC， China Labour and Social Security Publishing House, 2014, 2015, 2016.

Table A1 shows that the contribution to pillar one accounted for 62 percent of total contribution in the scheme 1 in 2012. It slightly increased to 62.9 percent in 2013 and stayed at 63.3 percent from 2014 to 2016. We use these shares and the total contribution in Column 2, Table 4 to calculate the amount of contribution of pillar one, Scheme 1. Then the contribution to pillar two is simply using the total contribution to subtract the contribution to pillar one. The results are displayed in Table A2. Similarly, we use the share of payment to pillar one in Table A1 and the total payment in Column 6, Table 4 to calculate the payments to pillar one. The results are also displayed in Table A2. Since pillar one has been running in deficit for several years (Based on China Pension Report 2012 (Zheng Bingwen, 2012)), we assume that the accumulated surplus of pillar one is 0 in our base year, 2012. Therefore, the accumulated surplus ¥2394.1 billion in 2012 in Table 4 will be allocated to pillar two, Scheme 1. From 2013 to 2016, the accumulated surplus (Stock) for pillar one is the calculated contribution (Column one, Table A2) plus the government subsidy (column 2, Table A2), then deduct the payment to pensioner (column 4, Table A2). There is no interest in 2013 because of the empty stock in 2012. We notice that the annual surplus of pillar one in 2013 is negative because the total expenditure (the payment) is larger than the total revenue, which is consistent with the actual situation in China.

Table A2: Revenues and Expenditures of PUE, pillar one (¥ billion)

	Contribution	Government Subsidy	Interest income and other	Total Revenue	Total Expenditure	Annual Surplus	Accumulated Surplus
	(1)	(2)	(3)	(4)	(5)	(6)=(5)-(4)	(7)
2012	1020.954	264.8	0	1285.754	1491.77	-206.0163	0
2013	1172.079	301.9	-12.3807	1461.598	1767.675	-306.078	-206.0163
2014	1286.924	359.368	-20.575	1625.717	2080.027	-454.3103	-512.0943
2015	1456.914	471.6	-32.97103	1895.542	2464.093	-568.5492	-966.4043
2016	1694.416	651.1	-48.15561	2297.358	3035.748	-738.3889	-1534.954

Source: Authors' calculation based the Bulletin on the Development of Human Resources and Social Security in China, 2012, 21013 and 2015; Annual Report on the Development of Chinese Social Insurance, 2014 and 2016.

Table A3: Revenues and Expenditures of PUE, Pillar 2 (¥ billion)

	Contribution	Government Subsidy	Interest income and other	Total Revenue	Total Expenditure	Annual Surplus	Accumulated Surplus
	(1)	(2)	(3)	(4)	(5)	(6)=(5)-(4)	(7)
2012	625.746	0	88.6	714.346	64.4283	649.9177	2394.1
2013	691.322	0	102.699	794.021	79.3258	714.6953	3044.018
2014	746.131	0	138.577	884.708	95.4734	789.2346	3758.713
2015	844.688	0	160.9	1005.587	117.2088	888.3792	4547.948
2016	982.387	0	177.9	1160.286	149.6526	1010.634	5436.328

Source: Authors' calculation based the Bulletin on the Development of Human Resources and Social Security in China, 2012, 21013 and 2015; Annual Report on the Development of Chinese Social Insurance, 2014 and 2016

Annex 2:

Table A3: Assumptions of Labour force participation rates of population aged 54 to 65

Year	Age											
	54	55	56	57	58	59	60	61	62	63	64	65
2019	74.21	71.09	68.66	67.17	65.35	62.19	53.98	51.38	49.14	46.73	44.42	41.8
2020	75	71.87	69.55	68.14	66.46	62.19	53.98	51.38	49.14	46.73	44.42	41.8
2021	75	72.66	70.44	69.11	67.56	62.19	53.98	51.38	49.14	46.73	44.42	41.8
2022	75	73.44	71.33	70.09	68.67	63.66	53.98	51.38	49.14	46.73	44.42	41.8
2023	75	74.22	72.22	71.06	69.78	65.13	53.98	51.38	49.14	46.73	44.42	41.8
2024	75	75	73.11	72.03	70.89	66.6	56.65	51.38	49.14	46.73	44.42	41.8
2025	75	75	74	73	72	68.06	59.32	51.38	49.14	46.73	44.42	41.8
2026	75	75	74	73	72	69.53	61.99	54.31	49.14	46.73	44.42	41.8
2027	75	75	74	73	72	71	64.66	57.25	49.14	46.73	44.42	41.8
2028	75	75	74	73	72	71	67.33	60.19	52.28	46.73	44.42	41.8
2029	75	75	74	73	72	71	70	63.13	55.43	46.73	44.42	41.8
2030	75	75	74	73	72	71	70	66.06	58.57	50.11	44.42	41.8
2031	75	75	74	73	72	71	70	69	61.71	53.49	44.42	41.8
2032	75	75	74	73	72	71	70	69	64.86	58.86	48.01	42.33
2033	75	75	74	73	72	71	70	69	68	60.24	51.61	42.87
2034	75	75	74	73	72	71	70	69	68	63.62	55.21	43.4
2035	75	75	74	73	72	71	70	69	68	67	58.81	43.93
2036	75	75	74	73	72	71	70	69	68	67	62.4	44.47
2037	75	75	74	73	72	71	70	69	68	67	66	45
2038-2049	75	75	74	73	72	71	70	69	68	67	66	45
2050	75	75	74	73	72	71	70	69	68	67	66	45

Source: The labour force participation rates in 2019 are the same as in 2010 which is from China Statistical Yearbook, 2017. Data from 2020 to 2050 are authors' assumptions.