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ESTIMATING THE IMPACTS OF DEMOGRAPHIC AND POLICY CHANGES ON PENSION DEFICIT

A Simple Method and Application to China

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Abstract

This article derives a simple method for projecting pension deficit as percent of GDP in future years based on commonly available population forecasting and a few predictable economic and policy variables. Compared with the classic basic equilibrium equation of pension funds, our new formula decomposes the retirees-workers ratio which mixes various kinds of impacts into three more-easily-predictable variables – the elderly dependent ratio, the prevalence of pension coverage, and the employment rate. Our illustrative application to China shows that gradually increasing the current low minimum age of retirement will largely reduce the pension deficit, under various demographic regimes. The pension deficit as % of GDP in the low fertility scenarios (which corresponds with keeping the current rigid fertility control policy unchanged in the long-run) would be 5.6-11.1, 3.8-6.3, and 9.0-13.8 times as high as that in the Medium Fertility & Medium Mortality scenarios in 2040, 2060, and 2080.

Introduction

Policymakers, the public, economic demographers, and economists, in general are very much concerned about the possible impacts of population aging on pension deficit as percent of GDP, which are likely the consequence of the relatively rapid growth of retirees and the shrinking of the working age population. Various models have been developed to project the pension deficit by academic scholars and governmental agencies in recent decades. For example, the World Bank's Pension Reform Options Simulation Tool-kit (PROST) is probably the most advanced and widely applied model that uses the actuarial method to project pension deficits. While it has ability to project the pension system's expenditure and revenues, the PROST model can also be used for other purposes, such as making pension system choices, modifying system rules, and determining appropriate contribution rates under different demographic and economic assumptions (World Bank 2002; Becker and Paltsev 2001). At present, there are more than 80 countries using the PROST model and software for their pension project and/or analysis. Using the PROST approach, Sin (2005) projected pension fund deficits in China under fourteen different scenarios in addition to addressing pension system choices, minimum age of retirement, and coverage options. Becker and Paltsev (2001) proposed a similar actuarial model as the PROST for a transitional country- Kyrgyz republic. They assessed the future trend of pension fund deficits under six scenarios with different demographic change and economic growth possibilities while focusing on alternative pension system options and a raise of minimum age of retirement.

Generally speaking, a typical actuarial model for pension deficit projections contains population, labor, pension, and macroeconomic modules (Becker and Paltsev 2001). Normally, the existing actuarial models need the following data in baseline year and each forecasted year: age-sex-specific data on fertility, mortality, immigration, labor force participation rates, unemployment rates, earnings profiles, contributors and pensioners, years of employment services at retirement, pension payments, retirement rates[1], and some non-age-specific macroeconomic indicators, such as GDP and its growth rate, and replacement rates (Becker and Paltsev 2001; Sin 2005). Some economic/finance forecasting models may also need age-sex-specific disability, survivor, and evasion and exemption rates (Becker and Paltsev 2001). Age-sex-specific data could provide more accurate information about the pensioner and contributors to the pension system given that the large differentials exist between males and females at different ages. However, such a large data requirement may not be met in developing and transitional countries, and it is extremely difficult to get needed good data for those decentralized systems that are run locally with different components and requirements. For example, a well-supported and well-organized World Bank study on China's pension system reform and projection only used data from seven provinces and local municipalities to project pension fund deficits, which might not accurately represent the whole country (Sin 2005). Becker and Paltsev (2001 indicated that the main purpose of the projection models for the pension fund deficits in transitional countries is illustrative rather than being intended for accurate revenue and expenditure forecasting, given that most transitional countries lack an adequate database to obtain robust results.

Another disadvantage of existing pension projections in transitional economies is that insufficient attention was paid to the demographics of possible changes in fertility, mortality, and migration (Becker and Bloom 1998). Empirical studies have shown that neglecting such demographic dynamics would create biases for pension fund balance projections (Becker and Paltsev 2001).

Moreover, complicated actuarial models require special expertise and skills and not easily accessible and understandable by the demographers and ordinary readers who are interested in exploring the impacts of possible changes in fertility, mortality and minimum age of retirement policies. Thus, developing a simple method for estimating the demographic, policy, and economic impacts on pension deficit as percent of GDP is of scientific and practical significance, which is the goal of this article. We will first derive a simple method for projecting pension deficit as percent of GDP based on a few macro economic and policy variables and commonly available existing population forecasting which depends on future changes in fertility, mortality, and migration. We will then apply this general method to the case of China and present comparative analyses between eight scenarios with different assumptions of fertility, mortality and minimum age of retirements to explore how may changes in fertility, mortality and policy concerning minimum age of retirement affects pension deficit as percent of GDP in China, the largest population in the world.

Derivation of a Simple Method for Projecting Pension deficit as percent of GDP

Let $W(t)$ denote the total number of workers; the term of "workers" in this article refers to those who work and participate in a pension program.

$R(t)$, total number of retirees in year t; the term "retirees" in this article refers to those who are retired and receive pension benefits.

$d(t)$, retiree-worker ratio in year t, namely, the ratio of total number of retirees to total number of workers in year t, $d(t) = \frac{R(t)}{W(t)}$

$AW(t)$, average wage per worker in year t;

$P(t)$, pension premium contribution rate in year t, namely, the proportion of total contributions to the pension fund premium by workers and employers among the total wages of all workers in year t;

$B(t)$, replacement rate in year t, namely, the ratio of the average retirement wage per retiree to the average wage per worker in year t;

If the total amount of the pension fund premium contributions by workers and employers is equal to the total pension payment to the retirees in year t, the following equation is held:

$$P(t) \cdot [AW(t) \cdot W(t)] = [B(t) \cdot AW(t)] \cdot R(t)$$

Dividing both sides of the above equation by $AW(t) \cdot W(t)$, we get:

$$P(t) = B(t) \cdot d(t) \qquad (1)$$

The above equation (1) is the classic basic equilibrium equation of pension funds (e.g., Becker and Paltsev 2001:19; Zhuo 2001; Cairns 2004; Hamayon and Legros 2001; Sin 2005). Based on this classic equation, we further derive a new simple method for projecting pension deficit as percent of GDP as follows.

Denote n(t) as the ratio of pension deficit (i.e. the difference between total pension premium contributions by workers and employers and the total pension payments to retirees) to the total wages in year t. n(t) can be positive (pension fund deficit), zero (balanced), or negative (pension fund surplus). The following equation is held:

$$P(t) \cdot [AW(t) \cdot W(t)] + n(t) \cdot AW(t) \cdot W(t) = [B(t) \cdot AW(t)] \cdot R(t)$$

Dividing the both sides of the above equation by $AW(t) \cdot W(t)$, we get:

$$P(t) + n(t) = B(t) \cdot d(t)$$

$$n(t) = B(t) \cdot d(t) - P(t) \qquad (2)$$

Note that the retirees-workers ratio (d(t)) in above equation (2) mixes the impacts of demographics, prevalence of pension coverage, and economic performance, which makes it extremely difficult to predict d(t) into the future years. Thus, we intend to express d(t) by a couple of more-easily-predictable variables. Let $d_2(t)$ denote the dependency ratio of elderly over minimum age of retirement, namely, the ratio of the total number of elderly persons over the minimum age of retirement to the total number of persons of labor force age (e.g. from age 18 to the minimum age of retirement). $d_2(t)$ can be derived from commonly available existing population forecasting. However, because not all persons over the minimum age of retirement are retired and receive pensions and not all persons of labor force age work for wages and participate in pension program, $d_2(t)$ and $d(t)$ are not equal to each other. We may rewrite the Eq. (2) as:

$$n(t) = B(t) \cdot d_2(t) \frac{d(t)}{d_2(t)} - P(t)$$

$$\frac{d(t)}{d_2(t)} = \frac{\text{total number of retirees} \big/ \text{total number of workers}}{\text{total number of persons over minimum retirement age} \big/ \text{total number of persons of labor force ages}}$$

We may rearrange the components of $\frac{d(t)}{d_2(t)}$ to make it easier for interpretation,

$$\frac{d(t)}{d_2(t)} = \frac{\text{total number of retirees} \big/ \text{total number of persons over minimum retirement age}}{\text{total number of workers} \big/ \text{total number of persons of labor force ages}}$$

Let r(t) denote the retirement rate (i.e., proportion of retirees who receive pensions among the total number of elderly persons over the minimum age of retirement) which is the numerator on the right side of above equation; e(t), the formal employment rate (i.e., proportion of the workers who participated in pension programs among the total number of persons of labor force ages) which is the denominator on the right side of above equation. Thus,

$$n(t) = B(t) \cdot d_2(t) \frac{r(t)}{e(t)} - P(t) \qquad (3)$$

We go one-step further to estimate PD(t), the conventional index of *pension deficit as percent of GDP*, through multiplying n(t) by SG(T), the total wages as percent of GDP:

$$PD(t) = [B(t) \cdot d_2(t) \frac{r(t)}{e(t)} - P(t)]SG(t) \qquad (4)$$

Eq. (4) has provided a simple and practical approach for projecting pension deficit as percent of GDP in the future years, based on:

(a) One demographic indicator (also reflecting the policy on minimum age of retirement) -- $d_2(t)$ (dependent ratio of elderly over minimum age of retirement);

(b) Two pension policy indicators -- $B(t)$ (replacement rate) and $P(t)$ (pension premium contribution rate), and one summary indicator of social welfare policy on the prevalence of pension coverage, including the extent of postponement of retirement -- r(t) (the retirement rate);

(c) One economic performance indicator -- e(t) (the formal employment rate) and another economic variable SG(t), total wages as percent of GDP.

Note that $d_2(t)$ has clear demographic and policy meanings and can be easily derived from commonly available existing population forecasting; B(t), P(t), and r(t) have clear policy meanings; e(t) and SG(t) have clear economic meanings; B(t), P(t), r(t), e(t), and SG(t) can be projected based on time series analysis or policy analysis with comparison with other populations at different stages of economic development or the expert option approach. Note that the retirees-workers ratio (d(t)) in the classic basic equilibrium equation of pension fund (Eq. (1)) mixes the impacts of demographics, prevalence of pension coverage, and economic performance, which makes it extremely difficult to predict d(t) into the future years. Our new Eq. (4) decomposes the hardly-predictable d(t) into three more-easily-predictable variables -- $d_2(t)$ (dependent ratio of elderly over minimum age of retirement), r(t) (prevalence of pension coverage) and e(t) (economic performance). Of course we should be aware that the demographic factor $d_2(t)$, policy factors B(t), P(t), and r(t), and the economic factors e(t) and SG(t) in Eq. (4) are all interactive with each other, and our simple method cannot identify the interaction effects.

In fact, if one believes that ratio of pension deficit to the total wage (n(t)) is sufficient to measure the pension financial gap, one may use simpler Eq. (3) to estimate n(x) as indicator of pension shortage. We, however, recommend using Eq. (4) to project pension deficit as percent of GDP since it is more directly intuitive to express the pension financial gap, and that the additional input of total wages as percent of GDP is usually available in the time series data set, rather stable, and relatively easy to predict.

If the main purpose of the study is to analyze the impact of changes in demographic regimes (i.e. fertility and mortality levels) and policy of minimum age of retirement on the pension deficit as percent of GDP in the future years, one may simply fix the changes (or no changes) of policies on pension benefits and premium contribution rates (B(t) and P(t)), social welfare and postponement of retirement (r(t)) and economic performance (e(t)), while focusing on scenarios with various combinations of different assumptions on changes in fertility, mortality and minimum age of retirement.

Illustrative application: the impacts of possible changes in fertility, mortality, and minimum age of retirement on pension deficit as percent of GDP in 2000-2080 in China

Data and assumptions for the scenarios

According to the statistics released by the China Ministry of Labor and Social Security, the replacement rate in 2000 (B(2000)) was 0.8789， the pension premium contribution rate in 2000 (P(2000)) was 0.1821. We adopt the research results on the forecasting of the replacement rate up to 2030 (B(2030) = 0.60) and the pension premium contribution rate up to 2050 (P(2050) = 0.36, (with 0.25 contributed by employees and 0.11 contributed by individual workers), released by the Institute of Social Security under the China Ministry of Labor and Social Security (He, 1998; 2001). The replacement rates between 2000 and 2030 and the pension premium contribution rates between 2000 and 2050 are estimated by linear interpretation. The replacement rates after 2030 and the pension premium contribution rates after 2050 are assumed to be unchanged. We employed the average of the high and low scenarios of the real annual growth rate of GDP and real annual growth rate of total wages from year 2000 to 2075 (Shin 2005) and then estimated the annual total wages as percent of GDP and GDP from 2000 to 2080.

Although the retirement rates (r(t)) and formal employment rate (e(t)) are predictable, it is very hard to do it in China so far because of the lack of time series data of good quality, and future uncertainties concerning economic performance and social welfare policy, such as whether and when the basic pension system may be implemented in rural areas. Even more importantly, the focus of our illustrative application to the new simple method in this paper is to analyze the impacts of possible changes in fertility and mortality levels and the policy of minimum age of retirement on the pension deficit as percent of GDP in the future years. Therefore, we assume that the ratio $\frac{r(t)}{e(t)}$ in Eq. (2) after year 2000 remains the same as what was observed in 2000.

The medium mortality scenario adopted in this study assumes that there will be rather gradual progress in reducing mortality in China during the first half of this century – from a life expectancy of 71.4 years for both sexes combined in 2000, to 78.1 in 2050, and 81.9 in 2080. This may be quite conservative; given the fact that life expectancy in Japan in 2003 was already 81.8 years[2]. Some recent research indicates that there might be a significant improvement in mortality in the first half of this century, because of biomedical advances and breakthroughs, and better personal health practices, such as healthy diets, not-smoking and exercise, etc. We, therefore, made another optimistic scenario, namely, life expectancy for both sexes combined was assumed to approach 84.8 in 2050 (Ogawa 1988), a level that is about 3 years higher than that in Japan in 2003. We also assume that life expectancy for the two sexes combined will be 88 years old in 2080[3]. This optimistic mortality scenario is subject to uncertainty, but we believe that it is not impossible. Some scholars thought that a life expectancy of 85 years represented the limit of human life expectancy (e.g. Fries et al. 1989; Olshansky et al., 1990; Olshansky Carnes, and Désesquelles 2001). However, most scholars now think that human beings can, on average, live much longer than 85 years (e.g. Manton et al. 1991; Vaupel and Gowan 1986; Guralnik et al. 1988; Vaupel et al. 1998; Oeppen and Vaupel 2002).

Despite uncertainty, the conservative and optimistic mortality scenarios bracket an informative range of possibilities in China during the first half of the next century.

The 2000 Chinese census reported an extremely low TFR of 1.22. This is obviously too low to believe. Based on our review of existing related studies (e.g. Guo, 2000), we assume a 25% under-reporting of birth rates, which implies that the TFR for rural and urban areas combined in 2000 was about 1.63; and the TFR in rural and urban areas was estimated as 1.9 and 1.15 in 2000[4]. In the low fertility scenario, we assume that the TFR will slightly increase from the 2000 level to 1.98 and 1.2 in rural and urban areas in 2012, and then remain constant (see Table 1). This low fertility assumption may reflect the implications of keeping the current extremely rigid fertility policy unchanged in the long run. In the medium fertility scenario, we expect that China will gradually relax its one-child policy, due to the current very low fertility level and the future population aging problems[5]. Thus, in the medium fertility scenario, we assume that the life-time cohort TFR will increase to 2.27 and 1.8 in rural and urban areas in 2012, and keep at this level afterward[6]. Because rapid socioeconomic development in China has been causing young people to delay their marriages and births (see data shown in Figure 1 of Zeng et al., 2005), we assume that the age at the first, second or higher order births will increase by 0.9 and 1.8 years during the years from 2012 to 2030, which constitutes an annual growth rate of 0.05 and 0.1 years, respectively. According to the Bongaarts-Feeney method (Bongaarts and Feeney 1998; Zeng and Land 2000; 2001), the projected period TFR of the first and second or higher order births in the years 2012-2030 will be 5% and 10% lower than the parity-specific cohort TFR, due to the fertility tempo effects. The overall TFR (all parities combined and rural/urban combined) in 2012 and 2030 will be

1.89 and 1.83, respectively. We assume that the increase in the age at childbearing will cease after year 2030, and by the year 2035, the period TFR will be the same as the cohort TFR and will remain constant thereafter(see Table 1).

---Table 1 is about here ---

We conduct eight scenarios with different combinations of Medium Fertility, Low Fertility, Medium Mortality and Low Mortality, and minimum age of retirement. In the scenarios of “gradual increase in minimum age of retirement” (scenarios 1, 2, 3, and 4), we assume that the minimum age of retirement will increase from 60 and 55 for men and women in 2000-2006, to 65 and 63 for men and women in 2030, 66 and 65 for men and women in 2050, and 67 for both men and women in 2080 (see Table 2). The “constant minimum age of retirement” in scenarios 5, 6, 7, 8 assumes the minimum age of retirement remains constant at the current level of age 60 and 55 for men and women.

1. Medium Fertility & Medium Mortality and a gradual increase in the minimum age of retirement;

2. Medium Fertility & Low Mortality and a gradual increase in the minimum age of retirement;

3. Low Fertility & Medium Mortality and a gradual increase in minimum age of minimum age of retirement;

4. Low Fertility & Low Mortality and a gradual increase in the minimum age of retirement;

5. Medium Fertility & Medium Mortality and a constant minimum age of retirement;

6. Medium Fertility & Low Mortality and a constant minimum age of retirement;

7. Low Fertility & Medium Mortality and a constant minimum age of retirement;

8. Low Fertility & Low Mortality and a constant minimum age of retirement.

-- Table 2 is about here ---

The impacts of a gradual increase in minimum age at retirement on pension deficit

The results of this study show that the pension deficit as percent of GDP in the scenarios of a gradual increase in minimum age of retirement (Figure 1 and Table 3) will be largely reduced as compared to the scenarios of constant minimum age of retirement (Figure 2 and Table 3), under any combination of medium fertility, low fertility, medium mortality, and low mortality. In the cases of Medium Fertility & Medium Mortality, which generally represents our educational guess of the future demographic changes, the pension deficit as percent of GDP under the assumption of a gradual increase in the minimum age of retirement will steadily decrease from 0.82% in 2000 to 0.45%, -0.06%, -0.48% in 2010, 2020, 2030, and then remain at a very low level with some fluctuations. In the other three less likely scenarios of Medium Fertility & Low Mortality, Low Fertility & Medium Mortality, Low Fertility & Low Mortality, gradual increases in minimum age of retirement will also lead to steady decreases in pension deficit as percent of GDP, negative percent (pension fund surpluses) in 2020 and 2030, and then increase but still remain at rather low level up to 2050-60.

---Figure 1 and Figure 2 are about here---

However, if China keeps its current very low minimum age of retirement unchanged in the long run, the pension deficit as percent of GDP will steadily and quickly increase in all cases of different combinations of fertility and mortality levels. Under the more likely Medium Fertility & Medium Mortality demographic regime, a constant minimum age of retirement will lead to a pension deficit increase from 0.82% of GDP in 2000 to 1.83%, 2.92%, and 3.73% of GDP in 2030, 2050, and 2080, in contrast to pension fund surpluses in 2020-2050 and around 0.3% thereafter in the scenario of a gradual increase in the minimum age of retirement with exactly the same demographic assumptions. In the other less likely demographic regimes, the pension deficit will be even much higher under the constant minimum age of retirement assumption: 1.96-2.07%, 3.54-4.62%, and 4.72-8.95% of GDP in 2030, 2050, and 2080, respectively.

--Table 3 and Table 4 are bout here--

In addition to the institutional and management problems in the current Chinese pension system, the very low minimum age of retirement (60 for men and 55 for women), which is indeed far from international standard, is one of the main causes of the current difficulties of pension funds in China. Our projection exercise indicates that China needs to revise its current policy concerning age at retirement, because if it were not revised, the pension deficit as percent of GDP will increase quickly to an unacceptable level under the various scenarios of demographic regimes. Our study also reveals that the current very low minimum age of retirement in China actually provides a good opportunity to face the challenges of pension fund deficits through gradually increasing the minimum age of retirement. Gradual increases in the minimum age of retirement plus viable reforms in pension system management will help China to move away from the difficulties of pension funds deficits. On the other hand, an increase in the minimum age of retirement, may reduce the job opportunities for younger people. Such possible negative effects may be avoided or reduced through investing more in job-creating businesses, especially in service industries, and prolonging the education period of young people. We believe that young people's job opportunities should not be used as a justification to keep the Chinese minimum age of retirement at the current very low level.

Impacts of the demographic changes on pension deficit

Comparing the four curves in Figure 1 and the four columns in Table 3, we can quantify the impacts of the possible demographic changes on the pension deficit as percent of GDP under the assumption of a gradual increase in the minimum age of retirement. Under the assumption of a gradual increase in the minimum age of retirement, the pension deficit as percent of GDP in the four scenarios with different combinations of fertility and mortality levels will not differ significantly up to the year 2030; the differences will increasingly become larger after 2030: the pension deficit as percent of GDP in the low fertility scenarios will be 5.5-11.1, 3.8-6.3, and 9.0-13.8 times as high as that in the Medium Fertility & Medium Mortality scenarios. This exercise shows that the impact of possible mortality changes on pension deficit as percent of GDP is likely moderate, but the negative impacts of keeping the very low fertility rate (which corresponds with keeping the current very rigid fertility control policy unchanged in the long-term) will be very large, especially after 2030 (see Table 3 and Table 4).

Under the assumption of a constant minimum age of retirement, the directions of the relative differences in pension deficit as percent of GDP among the four scenarios of different combinations of the fertility and mortality levels are similar to that under the assumption of a gradual increase in the minimum age of retirement; however, the pension deficit as percent of GDP in all of the four scenarios are, too high, especially in the scenarios with low fertility: 6-13%, 34-58%, and 97-140% higher than in the scenario with medium fertility and medium mortality in 2030, 2050, and 2080, respectively.

Conclusion

This article derives a simple formula for projecting the pension deficit as percent of GDP in future years based on commonly available existing population forecasting and a few predictable economic and policy variables. Compared with the classic basic equilibrium equation of pension funds (Eq. (1)), our new formula basically decomposes the retirees-workers ratio (d(t)) into three variables $d_2(t)$, r(t) and e(t). The retirees-workers ratio (d(t)) mixes the impacts of demographics, prevalence of pension coverage, and economic performance, which makes it extremely difficult to predict d(t) into the future years. Our new formula decomposes the hardly-predictable d(t) into three more-easily-predictable variables -- $d_2(t)$ (dependent ratio of elderly over minimum age of retirement), r(t) (prevalence of pension coverage) and e(t) (formal employment rate).

The illustrative application to China shows that the pension deficit as percent of GDP in the scenarios of gradual increases in the minimum age of retirement will be largely reduced as compared to the scenarios of a constant minimum age of retirement, under any combinations of medium fertility, low fertility, medium mortality, and low mortality. In situations of Medium Fertility & Medium Mortality, which generally represents our educational guess of the future demographic changes in China, the pension deficit as percent of GDP under the assumption of a gradual increase in minimum age of retirement will steadily decrease from 0.82% in 2000 to 0.45%, -0.06%, -0.48% in 2010, 2020, 2030, and then remain at a very low level with some fluctuations. In contrast, under exactly the same assumptions of Medium Fertility & Medium Mortality, keeping the minimum age of minimum age of retirement constant at the current level will lead to a pension deficit increase from 0.82% of GDP in 2000 to 1.83%, 2.92%, and 3.73% of GDP in 2030, 2050, and 2080.

Our projection exercise indicates that China needs to revise its current policy concerning age at retirement, because if it were not revised, the pension deficit as percent of GDP will increase quickly to an unacceptable level under various scenarios of demographic regimes. Gradual increases in the minimum age of retirement plus viable reforms for pension system management will help China to move away from the difficulties of pension fund deficits. On the other hand, however, increases in the minimum age of retirement may reduce the job opportunities for younger people. Such possible negative effects may be avoided or reduced through investing more in job-creating businesses, especially in service industries, and prolonging the education period of young persons.

Under the assumption of a gradual increase in the minimum age of retirement, the pension deficit as percent of GDP in the four scenarios with different combinations of the fertility and mortality levels will not differ significantly up to 2030; the differences will increasingly become much larger after 2030: the pension deficit as percent of GDP in the low fertility scenarios (keeping the current very rigid fertility control policy unchanged in the long-term) will be 5.6-11.1, 3.8-6.3, and 9.0-13.8 times as high as in the Medium Fertility & Medium Mortality scenario in 2040, 2060, and 2080, respectively. The exercise shows that the impact of possible mortality changes on the pension deficit as percent of GDP is likely moderate.

Although the simple method proposed in this article may be used to accurately forecast the pension deficit as percent of GDP in the short run-- if accurate input parameters of demographics, retirement and social welfare policies and formal employment rates can be accurately predicted-- the illustrative application to China presented in this article is not intended for accurate forecasting. This is because the assumptions adopted in the exercise for the 80 years projection horizon involve too many uncertainties. What we performed in this illustrative application is a "what if" exercise for policy analysis only and must not be interpreted as forecasting. For example, keeping the ratio of r(t)/e(t) constant is unrealistic, because the likely extension of the pension system from urban to rural areas, and further urbanization will certainly change the values of r(t) (retirement rate) and e(t) (formal employment rate). Perhaps in the early stages of the extension of the pension system from urban to rural areas, e(t) and P(t) will increase due to the increase in the rural pension premium contributors, thus reducing the pension deficit as percent of GDP; but in the later stages of the pension system expansion when the new rural contributors become eligible to receive pension benefits, r(t) will increase and thus will increase the pension deficit as percent of GDP. This again reveals that the very simple new formula proposed in this article can be used not only for policy analysis concerning minimum age of retirement and fertility as illustrated in this article, but also for policy analysis concerning expansion of the pension system from urban to rural areas.

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[1] A few actuarial models for pension deficit forecasts do not necessarily need the age-sex-specific data. For example, Hamayon and Legros (2001) developed a demo-economic model by linking production functions and demographic change. Although their model focuses on addressing the problems and consequences of the introduction of a funded component into a PAYGO system, it could also be used to forecast the pension deficit. It requires more economic data as compared to the PROST and Becker and Paltsev (2001), but it does not need to break data down to age-sex-specific. The models for the defined benefit pension system based on time series stochastic rates of return might also be used to forecast the pension fund deficit. These kinds of models are relatively more complicated and need much more statistical knowledge on the rates of return, although only aggregated data are required (e.g., Bedard 1999; Cairns and Parker 1997; Haberman and Wong 1997), and thus they are not applied as widely as other models.

[2] Source: Japanese Ministry of Health, Labor and Welfare;
http://www.mhlw.go.jp/english/database/db-hw/lifetb03/3.html

[3] We present assumed life expectancy for both sexes and rural/urban combined in the text due to space limits, but we actually used the sex-specific life expectancies for rural and urban sectors, respectively, in our projection exercise.

[4] The fertility and mortality in rural and urban China differ substantially and thus we should distinguish rural and urban differentials and include the rural-urban migration, which is what we have done concerning the Chinese population projection using the ProFamy software for the research reported in this article. However, the pension fund deficit rates projection cannot be done separately for the rural and urban sectors because of the complication of rural-urban mobility; the currently available methodology and data cannot deal with such complications. We, therefore, aggregate the forecasted rural and urban single-year-age-specific population and then estimate the pension deficit as percent of GDP for the country as a whole. Note that in limited areas with advanced economics, such as in the suburban areas of some cities in the east coast areas, the rural and urban residents are integrated in one uniform pension system. In many other rural areas, pension systems either do not exist or are still pilot programs, which are not yet integrated with the urban pension system which were established in the1950s. We assume that the future development of the rural pension scheme will be integrated with the urban pension system, since there is no good reason to further develop a separate pension system for rural areas.

[5] Various provinces in China have already started to gradually relax the one-child policy, such as allowing couples who are only-one-child (either both parties or one party) to have two children.

[6] Considering the relatively low level of socioeconomic development in rural areas and the fact that rural couples of minority ethnic groups are allowed to have more than 2 children, the lifetime cohort TFR in rural areas in and after the year 2012 is assumed to be 2.27. We assume that the lifetime cohort TFR in urban areas will be 1.8 in and after the year 2012, which implies that we assume that in urban areas 3% of women are in-fecund, and 14% voluntarily choose to have only one child.

Table 1. Rural and urban period TFR, and weighted average period TFR of rural and urban combined (using % of rural and urban as weights)

	2000	2012	2030	2035	2050	2080
Low fertility						
Rural	1.9	1.98	1.98	1.98	1.98	1.98
Urban	1.15	1.20	1.20	1.20	1.20	1.20
Total	1.63 (1.70)	1.61 (1.61)	1.50 (1.50)	1.47 (1.47)	1.40 (1.40)	1.28 (1.28)
Medium fertility						
Rural	1.9	2.09	2.09	2.27	2.27	2.27
Urban	1.15	1.67	1.67	1.80	1.80	1.80
Total	1.63 (1.70)	1.89 (2.05)	1.83 (1.98)	1.96 (1.96)	1.92 (1.92)	1.85 (1.85)

Notes:
(1) In both low and medium fertility scenarios, we assume that the proportion of the urban population will increase from 36% in 2000 to 47.4%%, 61.7%, 75%, and 90% in 2012, 2030, 2050, and 2080, respectively.
(2) Figures in the parentheses are the TFR adjusted for the effects of increasing mean age at birth, by the Bongaarts-Feeney method. When the increase in mean age at birth ceases, the tempo adjustment is zero.

Table 2. Assumption of minimum age of retirement

	2000		2006		2030		2050		2080	
Gender	male	female	male	female	male	female	male	female	male	female
Gradual increase in minimum age of retirement	60	55	60	55	65	63	66	65	67	67
constant minimum age of retirement	60	55	60	55	60	55	60	55	60	55

Table 3. Projected pension deficit as percent of GDP and the pension deficit (100 million RMB) with value compatible to 2001 in the scenarios with *gradual increase in minimum age of retirement* and different demographic regimes

		MF&MM Pension deficit		MF & LM Pension deficit		LF & MM Pension deficit		LF & LM Pension deficit	
		%GDP	RMB (100m)	%GDP	RMB (100m)	%GDP	RMB (100m)	%GDP	RMB 100m)
2000	89468	0.82	735	0.82	735	0.82	735	0.82	735
2010	182031	0.45	819	0.45	828	0.45	819	0.45	828
2020	310935	-0.06	-198	-0.03	-92	-0.06	-195	-0.03	-92
2030	494549	-0.48	-2385	-0.38	-1898	-0.43	-2134	-0.33	-1641
2040	732053	0.05	350	0.30	2193	0.26	1938	0.53	3893
2050	1032634	-0.16	-1639	0.32	3268	0.27	2743	0.79	8197
2060	1456632	0.33	4869	1.03	14982	1.26	18364	2.10	30606
2070	2054723	0.32	6505	1.07	21933	1.85	38086	2.87	59030
2080	2898390	0.23	6756	0.98	28260	2.09	60654	3.21	93078

Notes: (1) MF&MM: Medium Fertility & Medium Mortality; MF&LM: Medium Fertility & Low Mortality; LF&MM: Low Fertility & Medium Mortality; LF&LM: Low Fertility & Low Mortality; (2) RMB 100m: 100 million RMB; RMB is the Chinese currency; current I US dollar is equal to about 8.1 RMB.

Table 4. Projected pension deficit as percent of GDP and the pension deficit (100 million RMB) with value compatible to 2001 in the scenarios with *constant minimum age of retirement as it was in 2000* and different demographic regimes

		MF&MM Pension deficit		MF & LM Pension deficit		LF & MM Pension deficit		LF & LM Pension deficit	
		%GDP	RMB (100m)	%GDP	RMB (100m)	%GDP	RMB (100m)	%GDP	RMB 100m)
2000	89468	0.82	735	0.82	735	0.82	735	0.82	735
2010	182031	0.80	1459	0.81	1467	0.80	1459	0.81	1467
2020	310935	1.06	3299	1.10	3416	1.06	3299	1.10	3420
2030	494549	1.83	9038	1.96	9673	1.94	9591	2.07	10242
2040	732053	2.24	16429	2.56	18709	2.66	19463	2.99	21910
2050	1032634	2.92	30155	3.54	36601	3.91	40337	4.62	47709
2060	1456632	3.39	49330	4.28	62402	5.41	78778	6.55	95451
2070	2054723	3.34	68700	4.30	88435	6.12	125796	7.50	154103
2080	2898390	3.73	108072	4.72	136702	7.35	212997	8.95	259305

Note: the same as Table 3.

Figure 1. Pension deficit as % of GDP of scenarios with *gradual increase in minimum age of retirement*, and different combinations of Medium Fertility, Low Fertility, Medium Mortality and Low Mortality assumptions

Figure 2. Pension deficit as % of GDP of scenarios with constant minimum age of retirement as it was in 2000 and different combinations of Medium Fertility, Low Fertility, Medium Mortality and Low Mortality assumptions