A Projection of Spanish Pension System under Demographic Uncertainty

by

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Abstract

The objective of this paper is to carry out a projection of the pension expenditures under demographic uncertainty in Spain. In order to obtain a stochastic pension expenditure projection, as well as the number of pensioners and the number of contributors, we use a stochastic population projection. Demographic situation with respect to the pension system in Spain shows a dramatic change during the first half of this century. It will be relatively favorable during the first two decades due to the increasing participation and employment rates as well as due to the relatively small civil war generations occupying dependent old ages while the baby boom generations staying in working ages. Starting from around 2030, however, the situation is completely reversed as the baby-boomers start to retire from the labor market while the working age population consists mostly of much smaller baby bust generations. The financial situation of Spanish pension system appears to be affected significantly by the above mentioned demographic situation. During the first few decades it will enjoy a small surplus. Most importantly, the deficit during the subsequent decades will be large and increasing over time. In 2050, the deficit will be higher than 6% of GDP by the probability of 0.90, and will be higher than 15% by the 0.10 probability. In the same year, the range of the debt (accumulated deficit) will be between 77% and 260% of GDP by the 80% confidence interval.

Keywords: Pension Expenditures, Demographic Uncertainty, Stochastic Population Projections, Spanish Pension System.
JEL Codes: C53, H55, J11.

Resumen
El objetivo de este trabajo es llevar a cabo una proyección del gasto en pensiones bajo incertidumbre demográfica en España. Para obtener una proyección estocástica del gasto en pensiones, así como del número de pensionistas y del número de contribuyentes, utilizamos una proyección estocástica de la población. Los resultados indican que la situación demográfica con respecto al sistema de pensiones en España muestra un cambio dramático durante la primera mitad de este siglo. Será relativamente favorable durante las dos primeras décadas debido tanto al incremento en las tasas de actividad y empleo, como a las relativamente pequeñas generaciones de la guerra civil, que ocupan las edades dependientes, mientras que las generaciones del baby boom se encuentran entre la población en edad de trabajar. Sin embargo, la situación se invierte en torno al año 2030, cuando las generaciones del baby boom se comienzan a jubilar, mientras que la población en edad de trabajar está formada por las generaciones del baby bust, mucho menos numerosas. La situación financiera del sistema de pensiones en España se encuentra afectada perceptiblemente por la situación demográfica descrita. Durante las primeras décadas gozará de un pequeño superávit. Sin embargo, el déficit durante las décadas siguientes será elevado y creciente a lo largo del tiempo. En 2050, el déficit será superior al 6% del PIB con una probabilidad de 0.90 y será mayor que el 15% con una probabilidad de 0.10. En el mismo año, la deuda del sistema (el déficit acumulado) estará entre el 77% y el 260% del PIB, con un intervalo de confianza del 80%.

Palabras clave: Gasto en Pensiones, Incertidumbre Demográfica, Proyecciones Estocásticas de Población, Sistema de Pensiones en España.
Códigos JEL: C53, H55, J11.

1 Introduction

Population aging is often identified as a principal problem that social security system will face in this century. In particular, Spain will be one of the developed countries where the population aging will be most intense due to the persistently lowest fertility rate combined with the relatively high life expectancy among the developed countries. Consequently, the prospects of financial sustainability of the pension system are pretty pessimistic. Some studies have forecast that the pension expenditure will reach between 13% to 17% of GDP in 2050, and the corresponding debt will reach a level between 77% and 168% of GDP in 2050 (see Herce *et al.*, 1996; Herce and Alonso, 2000; Piñera and Weinstein, 1996; Jimeno, 2002; and Alonso and Herce, 2003, among others).

The previously mentioned papers use deterministic population projections to evaluate the sustainability of the pension system in the long term. This traditional population projection method consists in a particular combination of varying assumptions concerning fertility, mortality and migration during the projection period to represent uncertainty. But this scenario based method has several shortcomings (Lee, 1992 and 1999; and Lee and Tuljapurkar, 2001; Zubiri, 2003) in that it overrides the stochastic nature of demographic processes. As a result, it is difficult to ascertain the probability range within which the future population is likely to fluctuate. In contrast, the purpose of making a stochastic population projection is to provide a predictive distribution of the future population. This approach makes possible to establish confidence intervals of the projected population characteristics.

Our objective here is to carry out a projection of the pension expenditures under demographic uncertainty in Spain. In order to obtain a stochastic pension expenditure projection, as well as the number of pensioners and the number of contributors, we use a stochastic population projection. The forecasting program PEP was used to produce a stochastic forecast for the population of Spain in 2004-2050. Combining the stochastic population projection with pension system rules we obtain stochastic results of the pension system in Spain. In section 2, we describe the Spanish application of stochastic population projection for the period 2004-2050 and some main results. Section 3 describes the pension projection model, main assumptions used for future macroeconomic situation and the current pension rules which will be applied to the projection model. We discuss some main results in the section 4 and main conclusions in the section 5.

2 Stochastic Population Projections for Spain, 2004-2050

Our objective is to analyze the pension expenditure under demographic uncertainty in Spain. In order to obtain a stochastic projection of pension expenditure, as well as the number of pensioners, and the number of contributors, we need a stochastic population forecast. By stochastic forecast of a population we mean a joint predictive distribution of the future population vectors (Alho, 1999). Predictive distributions are first specified for the vital processes of fertility, mortality and migration. Together with the starting or jump-off population[1], the future age-and-sex-specific vital rates determine the induced predictive distribution[2] according to the cohort-component bookkeeping equation,

[1] Jump-off values of population and vital processes refer to the year inmediately before the forecast period, 2003 in our case.

[2] This distribution takes the place of the conventional projection variants or scenarios to describe uncertainty.

$$population_{t+1} = population_t + births_t - deaths_t + net\ migration_t$$

Before making the demographic forecasts, we must specify a jump-off population by age, and sex, and point forecasts for future vital rates. For a detailed description see Alho (2004).

We established the jump-off population for Spain using the population as of January 1, 2003, which was taken from the New Cronos database at the end of May, 2004[3] . Jump-off values of age- and sex-specific mortality rates were established by smoothing the observed values of years 1998-2002 and adjusting for increase during the period to match the level of 2002. Age-specific fertility rates in year 2002 were used to provide jump-off values. Jump-off values of net migration at year 2002 were specified based on the most recent officially reported values, and the age-structure of net migration was assumed to follow the pattern estimated from data in 1990-2000.

The production of simulated population counts is based on the assumption that point forecast is available for the vital rates. The point forecast for age- and sex-specific mortality was calculated by starting from the jump-off value and applying an age-specific estimated rate of decline until period 2048-2049. From these point forecast, survival probabilities were calculated by sex for each age and forecast year. For fertility, first, ultimate value for the total fertility rate between 15 and 49 years old was specified. The total fertility rates of the intermediate forecast years were obtained by linear interpolation. Births were generated for each year until 2049 using these age-specific fertility rates. With respect to migration, the jump-off values were assumed to persist for ten years. Then, a linear change to the ultimate level

[3]More recent population values are avaliable, but they are not used since we do not know the age-structure of net migration.

was assumed. The age structure of net migration was estimated from data in 1990-2000 and held constant for the rest of the forecast period. Finally, migration during the forecast period was handled in terms of additive net migration values that already incorporate the effect of mortality within the year of entry or exit.

Uncertainty of the population forecast is described in terms of probabilities, i.e., future values are considered as being random. We use simulations to establish an estimate of the predictive distribution of the future population by age and sex. Cohort-component method was applied 1500 times, with stochastically varying values for age- and sex-specific mortality, age-specific fertility, and net migration. The procedure is based on the so-called scaled model for error (Alho and Spencer, 1997), and is implemented by means of the computer program PEP[4]. Uncertainty is assumed to increase with forecast year. Error increments of each age and sex group have a constant non-negative autocorrelation and cross-correlation of errors across age are represented by an AR(1) process, whose correlation at lag 1 is also non-negative. A normal distribution was used to represent error increments for each age and sex-group. Any increasing pattern of error variances can be represented by a suitable choice of the scales of the model. Finally, uncertainty in fertility, mortality, and migration were assumed to be independent of each other[5].

[4]Program for Error Propagation (PEP) is a computer program that carries out stochastic propagation of error using simultion techniques. PEP was written at the Department of Statistics, University of Joensuu. Its application has been illustrated in Alho (1998). For details, see Sormunen, Alho and Spencer (1997).

[5]Autocorrelation parameters of error increments and cross-correlation parameters across age and sex in fertility, mortality and net migration are avaliable form the authors upon request.

2.1 Projection Results

The forecasting program PEP was used to produce a stochastic forecast for the population of Spain in 2004-2050. From the jump-off population, the point forecasts and the parameters of the expected forecast error model, PEP simulates a set of vital rates, calculates the resulting sample paths and the marginal predictive distributions for each forecast year of the future population vector by age and sex. This is repeated as many times as specified by the user, 1500 in our case.

Figure 1 shows the median forecast and the 50% and 80% prediction intervals for the population of Spain to 2050. Median population is increased-although not of monotonous form- during the projection period, reaching 44.50 millions of people in 2050. We can see how the uncertainty increases with the lead time of the forecast. With the 50% probability, the future population of Spain would lie between 39.49 and 49.82 millions, and between 35.65 and 54.76 with the 80% probability[6].

[*Insert* **Figure 1** *around here*]

A habitual way to represent the age structure of a population is by means of population pyramids. Figure 2 shows the stochastic versions of the population pyramids for the years 2004, 2025 and 2050, respectively. As expected, no variation is discernible across the distribution of simulations in 2004. In 2025, however, differences are clear across the distribution and much more apparent in 2050. The age pyramid for 2050 shows the effect of population aging. Even the most favorable case does not allow at all the age structure to recover its pyramidal shape. In addition, Figure 2 shows that the uncertainty

[6] The prediction intervals are not necesarily symmetric around the median forecast by definition (Alho, 1998).

is greater in the young ages than in the old ones. This fact is because the uncertainty in fertility forecast is higher.

[*Insert* **Figure 2** *around here*]

Ageing of the population may be shown best through the aged dependency ratio of the population. The aged dependency ratio is defined as the number of persons aged 65 and more over those aged between 15 and 64. It is a demographic measure of the burden posed by the elderly population on the active population. The results are shown in Figure 3. We can observe a rapid increase from 2030 due to the retirement of the baby-boomers. The median projection implies more than a doubling of the current ratio by 2050, from 0.25 to 0.67. The age dependency ratio in 2050 would be higher than 0.75 by the probability of 25%. At the other side of the distribution, the ratio will be below 0.54 by the probability of 10%. Put another way, by a 90% probability it will be at least twice the current rate. Similar patterns could be shown for total dependency and elderly ratios.

[*Insert* **Figure 3** *around here*]

Figure 4 shows the evolution of the life expectancies separately for men and women together with the 50% and 80% probability intervals of the simulations. The general pattern is that life expectancy will monotonically increase in the future. The median projection shows that the life expectancy at birth will increase from 76.6 to 86 for men and 83.4 to 90 for women by 2050. It can be seen that with a 10% probability life expectancy at birth will be higher than 91 years for men and 95 for women by 2050.

[*Insert* **Figure 4** *around here*]

3 Macroeconomic scenario, Pension System and Projection Model

3.1 Macroeconomic scenario

We describe the macroeconomic scenario that we adopt in the model of pension budget. This includes labor market indicators, productivity growth, etc.

For the labor market, given the real data for the base year (2000) of participation rate (pr_t), employment (er_t) and unemployment (ur_t), labor productivity and the working age population $\left(POP_t^{(16,\dots,64)}\right)$, we adopt some hypotheses for their behavior.

We assume that participation rate increase at the same rate observed in the present (pr_{cr}) until it reaches a maximum level (pr_{max}), the average of EU countries,

$$pr_t = \begin{cases} pr_{t-1}\left(1 + pr_{cr}\right), \text{ if } pr_{t-1} \leq pr_{max} \\ pr_{max},\ otherwise \end{cases}$$

with it, and given the working-age population projection, we calculate the active population ($ACTP_t$),

$$ACTP_t = POP_t^{(16,\dots,64)} pr_t$$

The unemployment rate is assumed to decrease linearly to reach 4.5% in 2015 and to stay constant thereafter. Therefore, the number of the unemployed (UP_t) is the active population calculated before multiplied by the unemployment rate in each year

$$UP_t = ACTP_t ur_t$$

Employed population of each period (EP_t) is calculated as the difference between the active population and the unemployed,

$$EP_t = ACTP_t - UP_t$$

Then, its growth rate (epr_t) is

$$epr_t = \frac{EP_{t+1} - EP_t}{EP_t}$$

To calculate the evolution of GDP, we use the accounting identity

$$gdpr_t = epr_t + lpr_t,$$

where lpr_t is the labor productivity growth rate. We adopt the labor productivity growth will increase linearly to reach 2.0 in 2019 and then constant thereafter, and we suppose that wage increases at the same rate as labor productivity.

One may argue about the plausibility of our assumptions on economic scenarios. We are aware that the assumptions are basically arbitrary. However, since the purpose of the paper is to show the probability distribution (ranges) than the levels, we believe that the results are not so sensitive to the assumptions.

The projection of the GDP growth for the next 50 years is shown in the graph below. Notice that the stochastic nature of the GDP growth is completely due to the stochastic nature in occupation rate which in turn is due to the stochastic vital rates of population. As we can see, potential GDP growth rate is decreasing until 2040.

[*Insert* **Figure 5** *around here*]

3.2 Spanish Pension System

Given the population projection and macroeconomic situations in the future, the pension model computes the number of pensioners and contributors, and the revenues and expenditures of pension system according to the current rules of pension system. In the following we describe current Spanish pension system which will be applied in the projection.

Contributors: Given the distribution of active population, the number of contributors (CON), classified by age (j), gender (s), contributor type (r), and year (t), increases by the same rate as the occupied population estimated under the previously described macroeconomic scenario, conditioned by the survival probability ($surp$) which depends on age and gender.

$$CON_{j,s,r,t} = [CON_{j,s,r,t-1}\,(1 + epr_t)]\, surp_{j,s,t}$$

The Unemployed: In the base year the number of unemployed who are receiving unemployment benefits is calculated from the Spanish Labor Force Survey (EPA), and for the subsequent years the unemployment rate change is applied to calculate the number of the unemployed, again both conditioned by the survival probability which depends on age and gender.

$$UUB_{j,s,r,t} = [UUB_{j,s,r,t-1}\,(1 + urc_t)]\, surp_{j,s,t}$$

Pensioners: With respect to pensioners, the entrants in each year is computed by multiplying the probability of entry into each type of pension ($oape$ for old-age pension and $otpe$ for other types of pension) and the population for each age and gender.

$$\begin{aligned} OTENT_{j,s,r,c,t} &= otpe_{j,s,r,c,t} POP_{j,s,t} \\ OAENT_{j,s,r,t} &= oape_{j,s,r,t} POP_{j,s,t} \end{aligned}$$

where c subscript means contingency, *i. e.*, type of pension different from the retirement pension (orphanhood, widow's pension, incapacity, or familiar favor). Therefore, the number of pensioners of each type ($OAPEN$ for old-age pensioners and $OTPEN$ for other types) in each year is the sum of the pensioners in the last year who survived and the entrants each year.

$$\begin{aligned} OTPEN_{j,s,r,c,t} &= OTPEN_{j,s,r,c,t-1} surp_{j,s,t} + OTENT_{j,s,r,c,t} \\ OAPEN_{j,s,r,t} &= OAPEN_{j,s,r,t-1} surp_{j,s,t} + OATENT_{j,s,rt} \end{aligned}$$

Revenue: With respect to the revenue, we assume that the computation base is the same as wage income, $COMB_{j,s,r,t} = W_{j,s,r,t}$, which is estimated by age, gender and contributor type in each year. As mentioned earlier, the revenue base is updated each year by the productivity growth rate.

$$COMB_{j,s,r,t} = COMB_{j,s,r,t-1} \left(1 + lpt_t\right)$$

Pension revenue in each year will be the sum of the product of the calculation base and the social security tax rate for each type of contributor.

Pension Benefit: With respect to pension expenditure, the pension benefit base (PBB) is computed as below

$$PBB_{i,t} = \left[PBB_{t-1} + PBB_{t-2} + \sum_{j=3}^{ab} W_{t-j} \left(1 + \pi\right)^{j} \right] \frac{1}{ab},$$

where ab is the number of years included in the computation[7], and π is the inflation rate.

Depending on the number of years of contribution (C) of each individual,

[7] In 2000, the number of years used to compute PBB was 12, 13 in 2001 and, from 2002, is 15.

the pension as the proportion of computation base (α) is calculated.

$$\alpha = \begin{cases} 0 \text{ if } C < 15 \\ 0.5 \text{ if } C = 15 \\ 0.5 + 0.3\,(C - 15) \ \text{ if } 16 \leq C \leq 25 \\ 0.5 + 0.3\,(C - 15) + 0.2\,(C - 25) \ \text{ if } 26 \leq C \leq 35 \\ 1.0 \text{ if } C > 35 \end{cases}$$

Early retirement penalty is 8 percentage points of pension for each year of advancement. Pension is updated by the inflation rate each year.

4 Projection of Spanish Pension System

The literature on the sustainability of pension system indicates population aging as one of the main problem facing the developed countries during the first half of this century. In this section, we examine this hypothesis focusing on the effect of population aging on pension system in Spain. We use a simple accounting model with 1500 stochastic population projection.

4.1 Contributors and Pensioners

Under the current pay-as-you-go pension system, one of the principal factors which determine the balance of pension system is the ratio between contributors and pensioners. Figures 6, 7 and 8 show the number of contributors, pensioners and their ratios during the period 2004-2050. Given that the macroeconomic situations (participation, employment and unemployment rates) are deterministic for the whole projection period, the variations are totally due to the uncertainty in future demographic situation.

The number of contributors increases substantially during the first 15 years of the projection. This can be attributed to four factors: increasing participation rate, decreasing unemployment rate, substantial net immigration and the baby boom generations occupying the ages of high participation and high employment. Starting around 2025, the number of contributors decreases to reach 16 millions by 2050 according to the median projection.

On the other hand, the number of pensioners remains almost constant at around 8 millions during the first 10 years. This seems to be due to the entry of the relatively small civil war generations (those who are born in late 1930s and early 1940s) into retirement and the low female participation rates experienced by the female population at the ages of retirement during this period. However, the increase in the number of pensioners starting from 2015 will be substantial and continuous until the end of the projection period. The number of pensioner will almost double during the subsequent 30 years to reach 15 millions around 2045.

Consequently, the ratio between contributors and pensioners will increase in the beginning, from 2.1 in 2004 to 2.3 in 2011 before it starts to decrease. In the long-term, the decrease in the contributors/pensioners will be substantial, reaching one at the end of the projection period. That is, in less than 40 years of time (2011-2050) the ratio will decrease by 65% according to the median projection. In 2050, the ratio will range between 0.8 and 1.3 by the 80% confidence interval, that is, by a 90% probability it will be lower than 1.3.

[*Insert* **Figure 6** *around here*]

[*Insert* **Figure 7** *around here*]

[*Insert* **Figure 8** *around here*]

4.2 Pension Expenditure and Revenue

Pension expenditure as a share of GDP stays almost constant until 2015 reflecting the favourable situation in the ratio between contributors and pensioners. From then on, the expenditure increases incessantly, reaching 20 percent of GDP in 2046. This increase is almost the same proportion as the decrease in the contributor-pensioner ratio during the period. There is a 10% chance that it will be higher than 25.4%, and, on the other side a 10% chance that it will be lower than 16.8%. That is, by the 90% of probability the pension expenditure as a share of GDP will more than double during the period 2010-2050.

[*Insert* **Figure 9** *around here*]

Consequently, the pension budget balance shows a small surplus until 2021 according to the median projection, but an increasing deficit in the long run. The pension budget deficit will reach 10% of GDP by 2050. In this year, the deficit will be higher than 6% of GDP by the probability of 90%, and will be higher than 15% by the 10% probability.

[*Insert* **Figure 10** *around here*]

Finally, if we look at the pension debt, which is accumulated deficit over time, it will reach 152% GDP in 2050 according to the median projection. In the same year, the range of the debt will be between 77% and 260% by the 80% confidence interval. However, in the beginning it will enjoy a favourable situation until 2030.

[*Insert* **Figure 11** *around here*]

5 Conclusions

Demographic situation with respect to the pension system in Spain shows a dramatic change during the first half of this century. It will be relatively favorable during the first 2 decades due to the increasing participation and employment rates as well as due to the relatively small civil war generations occupying dependent old ages while the baby boom generations staying in working ages. Starting from around 2030, however, the situation is completely reversed as the baby-boomers start to retire from the labor market while the working age population consists mostly of much smaller baby bust generations.

The financial situation of Spanish pension system appears to be affected significantly by the above mentioned demographic situation. During the first few decades it will enjoy a small surplus. Most importantly, the deficit during the subsequent decades will be large and increasing over time. In 2050, the deficit will be higher than 6% of GDP by the probability of 90%, and will be higher than 15% by the 10% probability. In the same year, the range of the debt (accumulated deficit) will be between 77% and 260% of GDP by the 80% confidence interval.

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A Figures

Figure 1. Stochastic forecast of the population of Spain to 2050. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

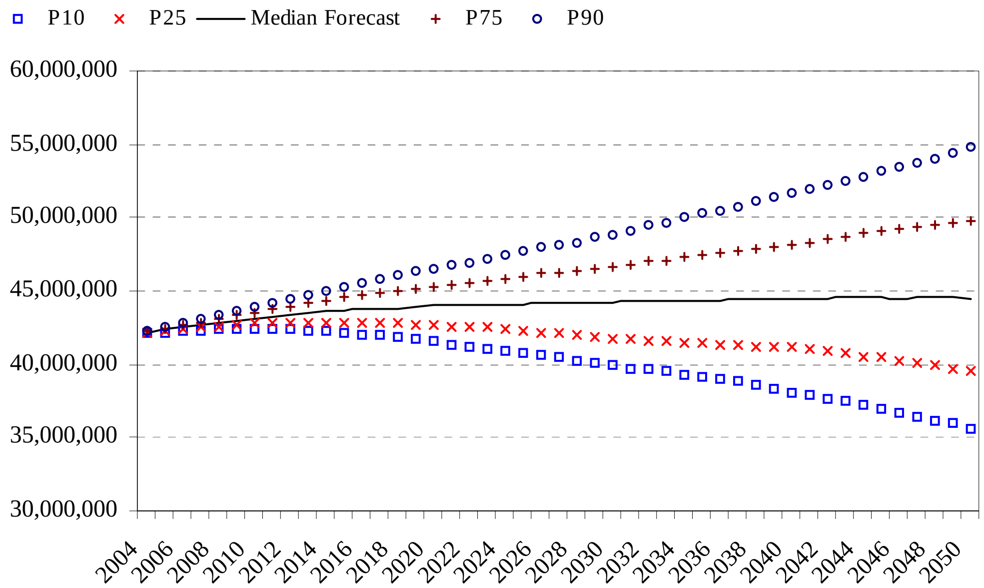


Figure 2. Population pyramids for Spain. Median forecast and 50% $[P_{25}, P_{75}]$ prediction intervals

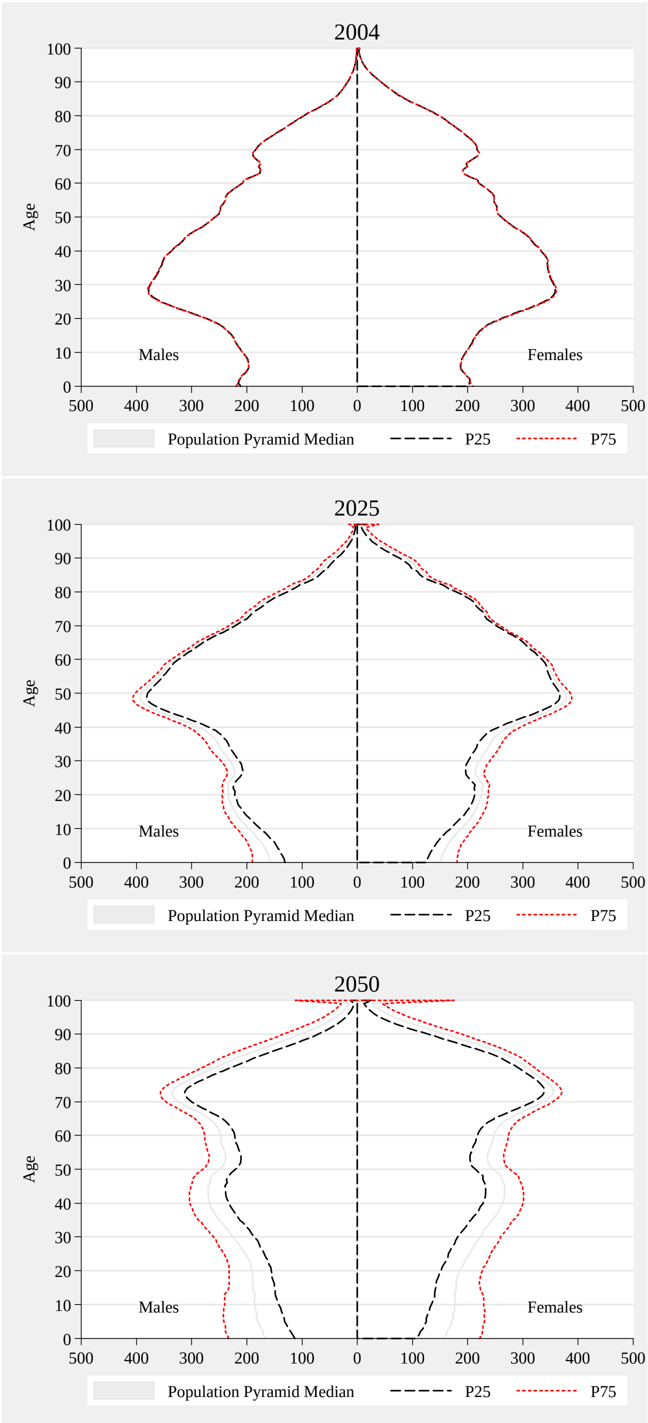


Figure 3. Aged dependency ratio to 2050. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

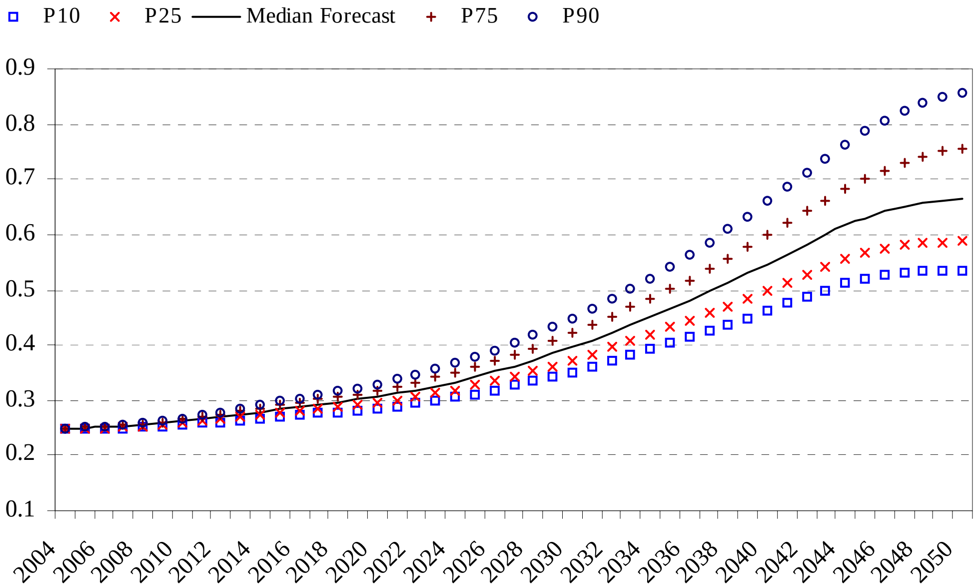
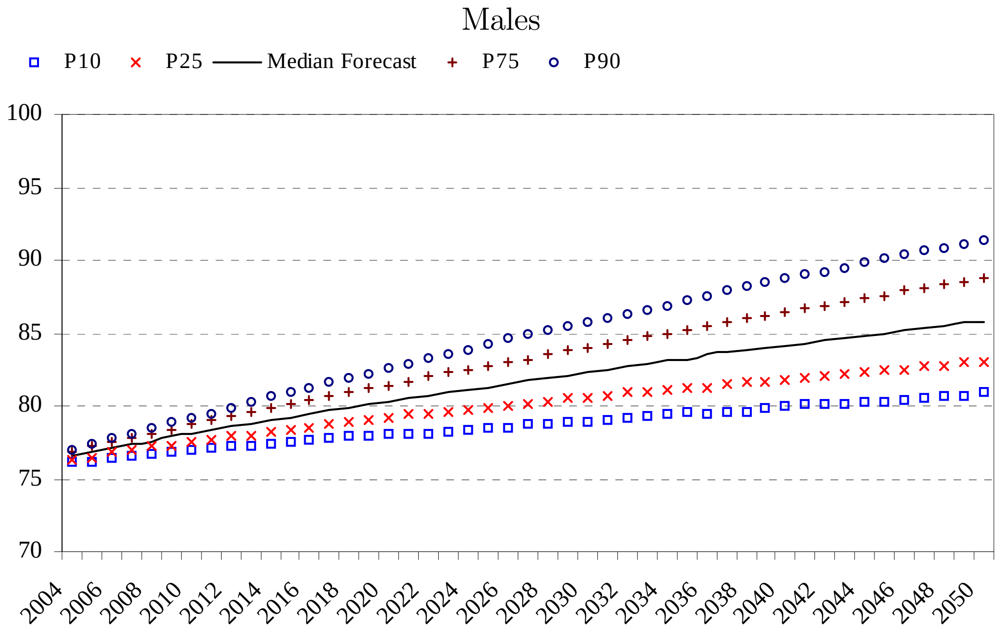


Figure 4. Stochastic forecast of the life expectancies at birth to 2050. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals



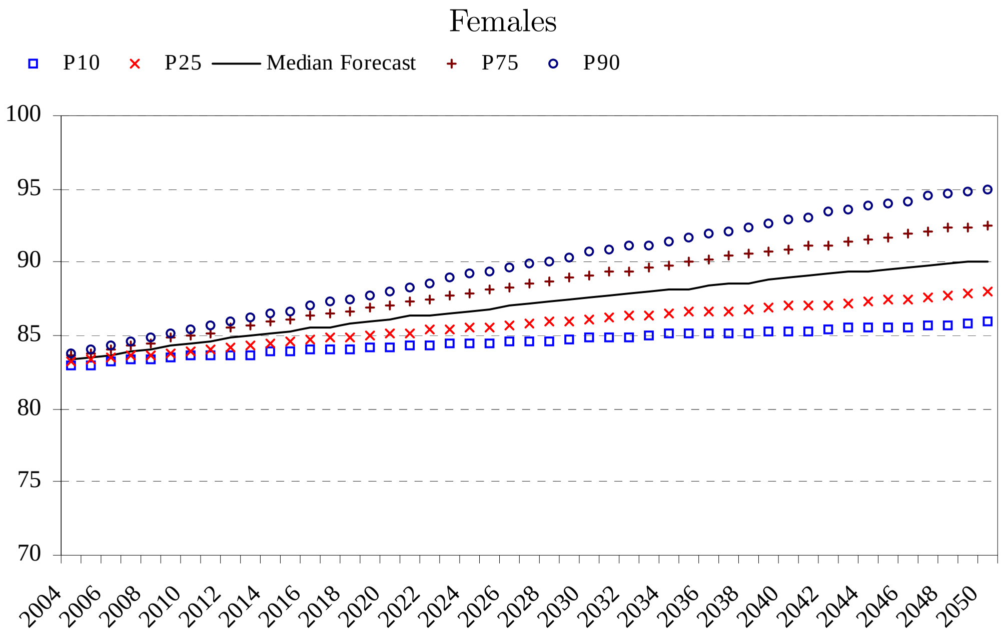


Figure 5. Projection of GDP growth rate. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

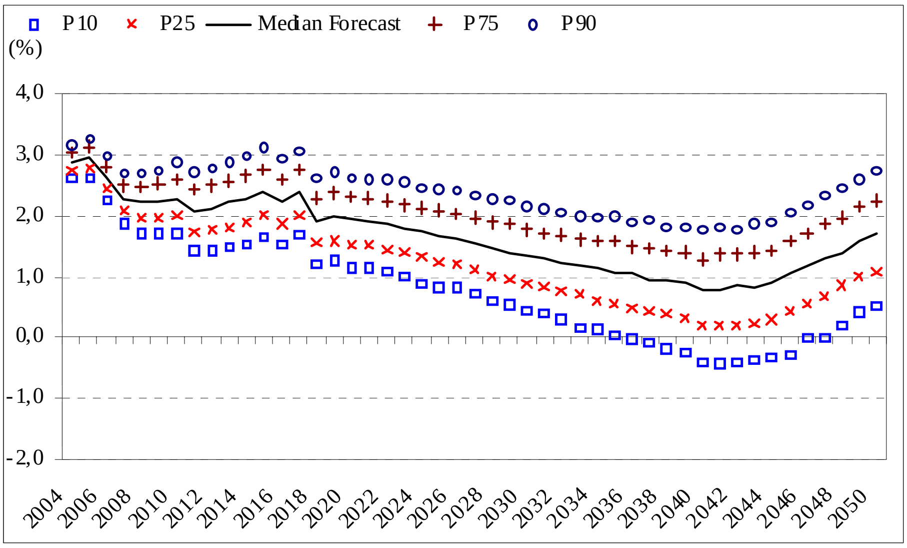


Figure 6. Projection of the number of contributors. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

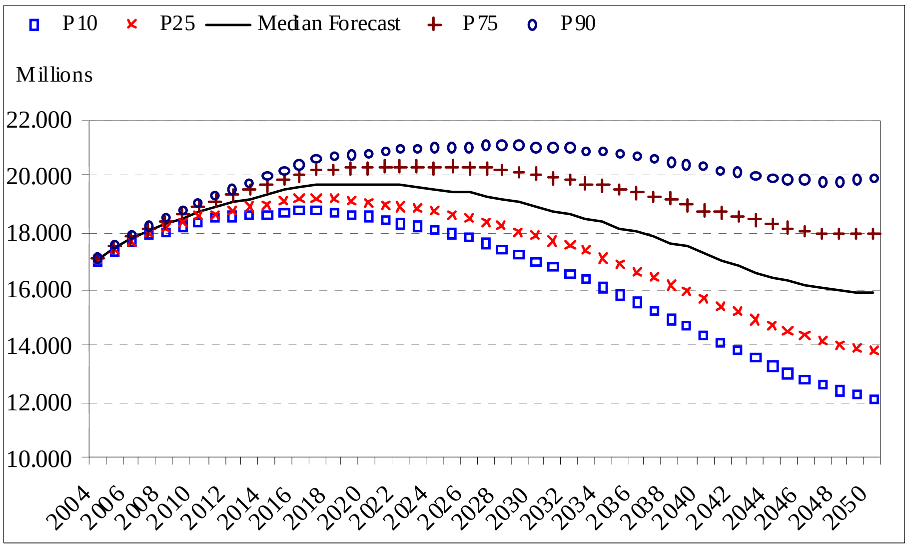


Figure 7. Projection of the number of pensioners. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

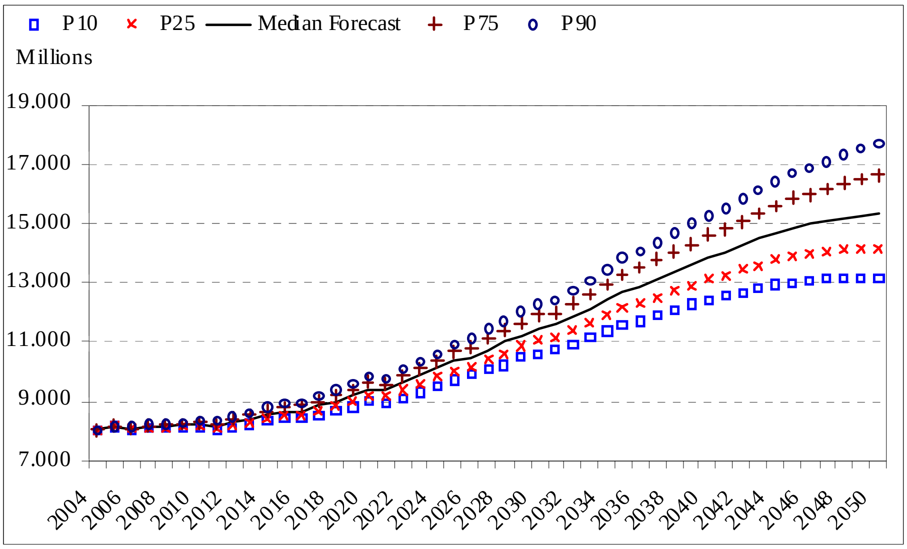


Figure 8. Projection of the ratio contributors/pensioners. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

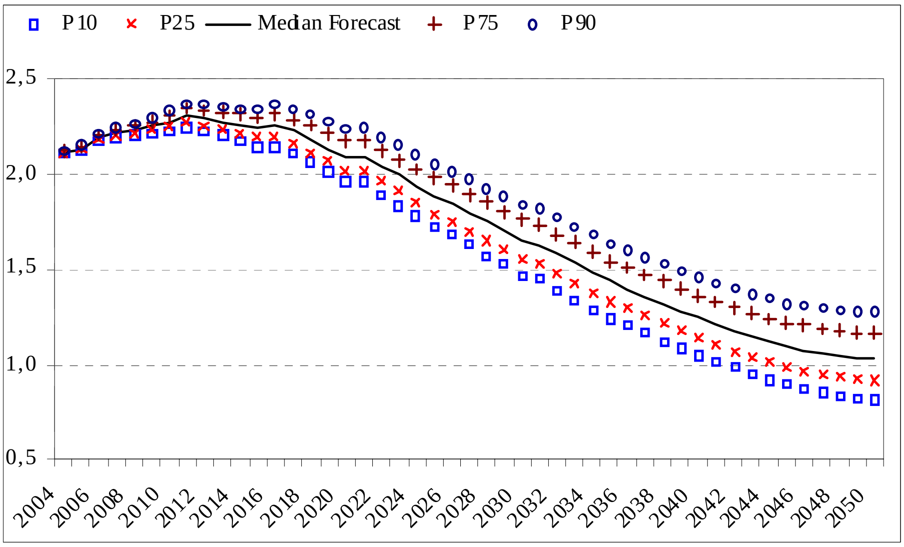


Figure 9. Projection of pension expenditure as % of GDP. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

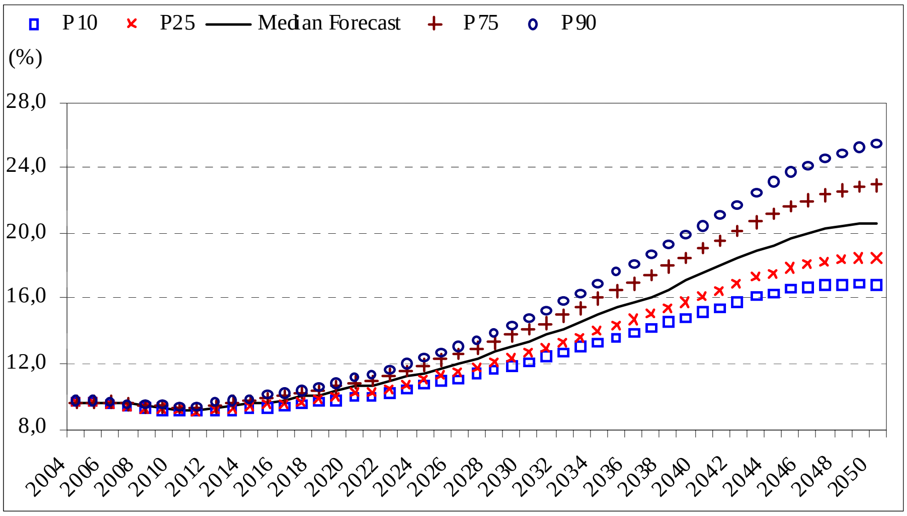


Figure 10. Projection of balance of pension system as % GDP. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals

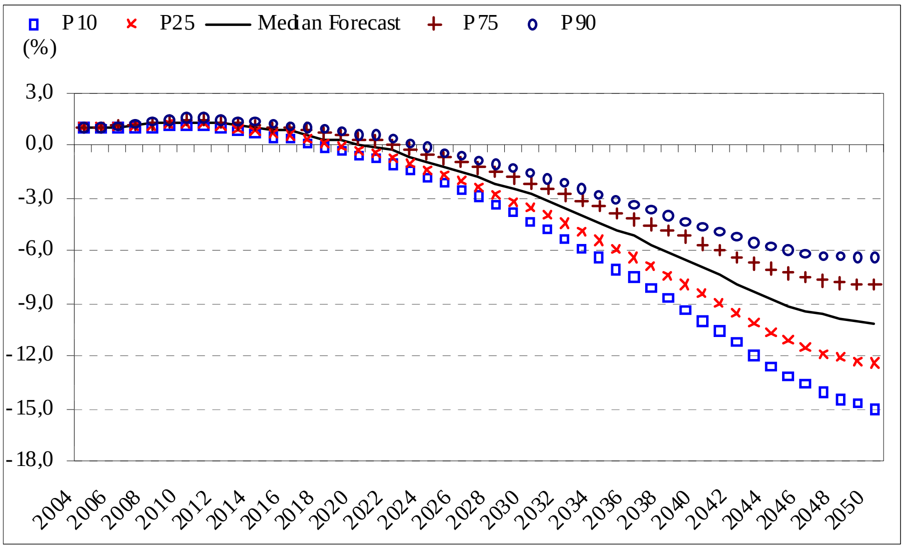
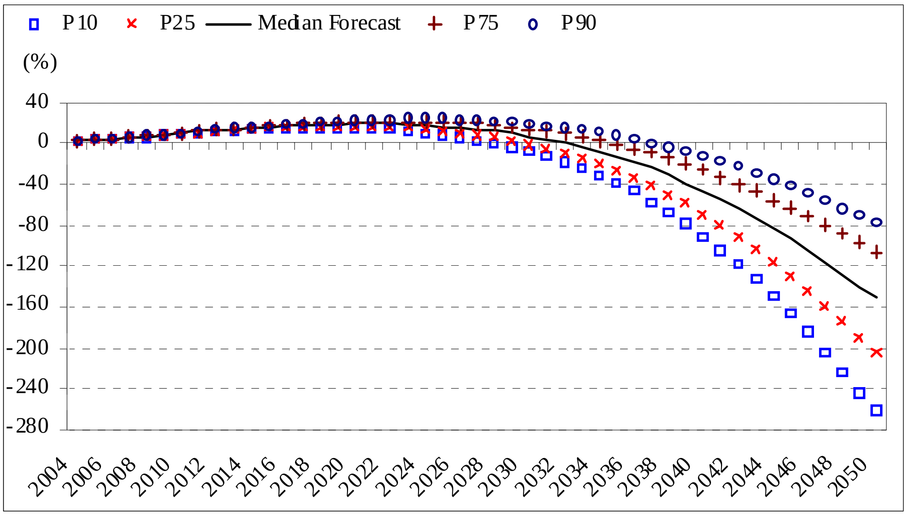


Figure 11. Projection of debt of pension system as % of GDP. Median forecast, 50% $[P_{25}, P_{75}]$ and 80% $[P_{10}, P_{90}]$ prediction intervals



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