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The impact of demographic uncertainty on public finances in the Netherlands[1]

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Abstract in English

The expected increase in the ratio of retirees to workers that is due to population ageing is sure to increase pressure on public finances and the Dutch economy in the coming decades. However, because of the uncertainty regarding future demographic developments, the exact extent of the problem is unknown. This paper presents stochastic simulations, *i.e.* simulations that combine the CGE model of the Dutch economy GAMMA with stochastic population projections.

Key words: Demographic Uncertainty, Public Finance, Stochastic Simulations.

JEL codes: C68, H68, J11

Abstract in Dutch

Doordat de verhouding gepensioneerden/werkers als gevolg van de vergrijzing toeneemt, is er een groeiende druk van de overheidsfinanciën op de Nederlandse economie. De demografische ontwikkelingen zijn onzeker waardoor de exacte omvang van deze groeiende druk onbekend is. Dit Discussion Paper doet verslag van stochastische simulaties met een algemeen-evenwichtsmodel van de Nederlandse economie (GAMMA) waarmee stochastische bevolkingsprojecties worden doorgerekend.

Steekwoorden: Demografische onzekerheid, Overheidsfinanciën, Stochastische simulaties.

Contents

Summary

The expected increase in the ratio of retirees to workers that is due to population ageing is sure to increase pressure on public finances and the Dutch economy in the coming decades. However, because of the uncertainty regarding future demographic developments, the exact extent of the problem is unknown. This paper presents stochastic simulations, *i.e.* simulations that combine the CGE model of the Dutch economy GAMMA with stochastic population projections. Stochastic simulation analysis produces frequency distributions rather than point estimates. This allows a specification of confidence intervals for vital statistics, like the elderly dependency ratio, public expenditures on health care and pensions, public revenues and finally, the sustainability gap, a measure for the indebtedness of the government. Moreover, the paper presents frequency distributions for three different policies that restore fiscal sustainability, namely a reduction of public expenditure, an increase of the rate of consumption taxation and an increase of the rate of labour income taxation. As the three policies differ in the degree to which they distort the labour market, their frequency distributions have different shapes.

1 Introduction

As with other European countries, the effects of population ageing on the sustainability of public finances in the Netherlands are well documented. Two recent studies, Van Ewijk *et al.* (2006) and European Commission (2006), conclude that current fiscal arrangements are inadequate to cope with the pressures that will be caused by the expected increase in the proportion of retirees to working-aged individuals in the coming decades. While there is little doubt that reforms must be implemented, the exact extent of the required policy adjustments is subject to uncertainty.

Uncertainties that are relevant for making fiscal projections may be broadly classified into two categories: economic uncertainties (regarding productivity growth, interest rates, labour participation etc.) and demographic uncertainties (regarding rates of fertility, mortality and net immigration). While economic uncertainties are mostly given ample attention, demographic uncertainties are often neglected. In a long-term analysis, demographic uncertainties may be equally relevant however. An analysis that deals exclusively with demographic uncertainties may contribute to correcting this imbalance.

Traditionally, projections that deal with (demographic) uncertainty distinguish between different scenarios: for example, high, medium and low variants. This approach suffers from a number of shortcomings (Lee and Tuljapurkar (2001)). Different scenarios assume perfect correlation of shocks over time and perfect (positive or negative) correlation between different variables. In addition, since they do not refer to the distribution of variables, it is difficult to select scenarios that have a similar likelihood of occurrence. Actually, the likelihood of any scenario is almost zero in a statistical sense, rendering the whole exercise difficult to give a proper interpretation.

In recent years, the field of statistical demography has developed an alternative to scenario analysis in the form of stochastic population forecasting (Alho (1990), Lee (1992)). This technique can be used to solve the shortcomings of the traditional approach. On top of that, the technique of stochastic simulations can say something about the expected value of a variable that is nonlinearly linked to demographic variables - information that cannot be obtained from a scenario approach. It is true that stochastic simulation analysis is more demanding, as it requires researchers to make explicit their assumptions about the joint frequency distribution of exogenous variables. This should be considered an advantage, though, as it renders the projection exercises more transparent.

This paper combines the computable general equilibrium model of the Dutch economy GAMMA with stochastic population projections. This enables us to produce predictive distributions not only for demographic variables like the size and the age structure of the population, but also for economic variables like GDP or fiscal variables like expenditure on health care or pensions. These predictive distributions can be given a probabilistic interpretation (Lee and Anderson (2005), Weale (2007)). If applicable, we will plot these distributions as a function of time, producing a number of illustrative ‘fan charts’ (Lee and Tuljapurkar (2001), Celasun *et al.* (2007)).

The GAMMA model is a behavioural model that incorporates the consumption-saving and labour-leisure decisions of households. This distinguishes the GAMMA model from standard generational accounting (GA) models, which are more often used to assess the implications of ageing populations. The relevance of this is that using stochastic forecasts in GAMMA may produce more realistic outcomes than they would in a GA framework. This is true in particular when policy changes are investigated that impact the households’ saving or labour supply decisions. (See Draper *et al.* (2006) for a more detailed discussion of CGE models like GAMMA and GA models.) This paper will illustrate this for the case of predictive distributions for tax rate changes.

In using GAMMA to conduct this analysis, a balance was struck between realism and tractability. We wanted to concentrate on the effects of demographic uncertainty and so, in choosing a model that is otherwise deterministic, the simulation outcomes are to some extent stylized. Nonetheless, we consider this approach to be a reasonable first-order representation of the issues involved and a vast improvement over the traditional method of conducting scenario analyses with non-behavioural accounting models.

The structure of this paper is as follows. Section 2 outlines the relevant details of the GAMMA model and explains how it is integrated with the stochastic forecasting program PEP. Sections 3 and 4 present our predictive distributions. Section 3 focuses on demography and section 4 discusses the development of public finances. Section 5 presents results that relate to the sustainability gap - a statistic that measures the policy adjustment required to sustain public finances indefinitely. Section 6 concludes the paper with a brief discussion. A supplementary collection of tables of summary statistics is given in the appendix.

2 PEP and the GAMMA model

We derive demographic data from two distinct sources. Fertility, mortality and net immigration rates in the baseline projection are taken from Statistics Netherlands (CBS). The deviations of these variables in typical stochastic demographic simulations from their counterparts in baseline simulation are taken from the PEP program (Program for Error Propagation), developed by Juho Alho and Bruce Spencer.

2.1 PEP

The PEP program applies random shock processes to the rates of change of fertility, mortality and net immigration.[1] The values of parameters are chosen such that the model mimics historical forecast errors made in population predictions.

Fertility, mortality and net immigration are modelled as independent from one another. Furthermore, demographic developments are assumed to be independent of economic variables. The stochastic population model can be described as follows.[2] Let $R(j,t)$ denote the value of a vital demographic process (such as the fertility, mortality or net immigration rate) for age j in the forecast year $t > 0$. Then:

$$R(j,t) = \exp(\hat{r}(j,t) + X(j,t))$$

where $\hat{r}(j,t)$ represents a given point forecast and $X(j,t)$ represents the error process. The error process takes the form $X(j,t) = \varepsilon(j,1) + ... + \varepsilon(j,t)$ with error increments:

$$\varepsilon(j,t) = S(j,t)(\eta_j + \delta(j,t))$$

$S(j,t)$>0 are scaling weights that replicate the increase in the variance of the error increments through time. The term η_j represents the error in the forecasted trend and $\delta(j,t)$ represents random fluctuations around the trend which are assumed independent over time for each *j*. The variables η_j and $\delta(j,t)$ are assumed to be independent of each other and:

$$\eta_j \sim N(0,\kappa_j),\ \delta(j,t) \sim N(0,1-\kappa_j)$$

with $0 < \kappa_j < 1$. In the version of PEP used in this study the two errors terms take a constant correlation structure:

[1] The PEP program does not model immigration and emigration separately; instead, it models net immigration..

[2] This description draws on Alho and Spencer (1997).

$$Corr(\eta_i,\eta_j)=\rho_\eta, Corr(\delta_i,\delta_j)=\rho_\delta$$

with $|\rho_k|\leq 1,\ \ k=\eta,\delta$.

So to run PEP, the user must specify, for each vital rate, a point forecast $\hat{r}(j,t)$, the values of the scaling factors $S(j,t)$ and the values of the parameters κ_j , ρ_η and ρ_κ. As stated above, the point forecasts are taken from the CBS. The model parameters that determine the stochastic processes are taken from the UPE (Uncertain Population of Europe) project[3] and apply specifically to the Netherlands. While the scale of the assumed errors in forecasting are based on the expert judgement of the model builders, they are not the result of a statistical estimation procedure.

The output of the stochastic processes are cohort-specific estimates of fertility rates (for females aged 15 to 49), mortality rates (for males and females aged 0 to 99) and net immigration rates (for males and females aged 0 to 99) extending 50 years into the future. The structure of the model is such that the logarithms of fertility rates, the logarithms of mortality rates and the rates of net immigration are normally distributed. This procedure is considered to be a conservative characterization of the uncertainty surrounding future demographic developments, in that catastrophic events such as pandemics or a third world war are not considered. On that account, demographic uncertainty may be underestimated.

While PEP produces population forecasts that extend 50 years into the future, our economic model, GAMMA, requires demographic input covering 200 years. To bridge this difference we extrapolate the stochastic processes of PEP forward by fixing all fertility rates, mortality rates and net immigration rates in the period 2057-2205 to their 2056 values. This ensures that in each projection, the population growth rate converges to a constant and the elderly dependency ratio stabilizes in the long run. This assumption satisfies a technical requirement of the simulation procedure; that a steady state is reached in the final years of the projection period.

2.2 GAMMA

GAMMA is an applied general equilibrium (AGE) model of the Netherlands that features overlapping generations of households and a thorough elaboration of the interaction between the private and public sector based on generational accounting (GA) principles.[4] Like other AGE models in the Auerbach-Kotlikoff tradition (1987), GAMMA accounts for feedback mechanisms caused by household behavioural responses to policy reforms. Using a GA framework enables far-sighted assessments to be made of the effects of demographic changes

[3] See http://www.stat.fi/tup/euupe/del12.pdf.

[4] For a detailed technical description of GAMMA, see Draper and Armstrong (2007).

on the sustainability of public finances and the pension system. In this way, GAMMA combines the best aspects of AGE and GA models.

Each household in GAMMA is represented by a finitely-lived adult whose economic behaviour is guided according to life-cycle theory. Households maximize their expected lifetime utility subject to a budget constraint by choosing a time path of total consumption. Lifetime expenditure is constrained by total wealth, which equals the sum of financial wealth and the discounted value of potential future labour and pension income.[5] Total consumption consists of both commodity and leisure consumption, so the labour supply decision results from the household utility maximization problem as well. Taste shift parameters that determine the leisure and goods consumption preferences for each age cohort are calibrated with estimated lifetime consumption and labour profiles of the Netherlands. Agents have perfect foresight; that is, their expectations coincide with realisations. Lifetime uncertainty is recognised, but perfect capital markets enable households to insure against this type of risk.[6]

GAMMA considers the Dutch economy to be small relative to the outside world. In particular, goods produced at home are perfectly substitutable with those produced abroad, so commodity prices are determined by the global market. Domestic policies do not affect the interest rate, which is determined on world capital markets. Production takes place with labour and capital according to a CES production technology. The model assumes a perfect labour market: wage accommodation takes place without any delay. The productivity of labour is assumed to depend on age. Otherwise labour supplied by households of different ages is homogeneous. Capital also adjusts without any delay.

The modelling of the public sector is different from the other actors in the model (households, firms, pension funds) in that its behavioural relations are more or less automatic rather than derived from some optimization problem. This approach is quite obvious when the analysis aims at assessing the sustainability of current fiscal policies or when it aims at exploring the effects of certain changes in public policies. Alternative approaches exist however. See for example, Celasun *et al.* (2007) for an analysis that explicitly accounts for fiscal reaction functions.

Revenues for the public sector consist of contributions to the public pension scheme and receipts from profit, income and indirect taxation. Expenditures on age-sensitive items such as health care, education and public pensions have their own age profiles so aggregate expenditures on these items develop from year to year accordingly along with demographic changes. In addition they grow over time in proportion to the wage rate. In contrast, all individuals are assumed to receive the same benefit from spending on non-age-sensitive items like defence and public administration. On the aggregate level, these expenditures rise with GDP.

[5] Potential labour income is defined as income with labour time equal to the total available time.

[6] Longevity risk is assumed to be diversified; each household receives an annuity from a life insurance company in return for bequeathing it its remaining assets upon death (Yaari (1965).

GAMMA distinguishes also supplementary (second-pillar) pension schemes. This is important for fiscal reasons: pension premiums can be deducted from income before taxes are determined, while pension benefits are taxed. Furthermore, the pension scheme may (positively or negatively) affect labour supply decisions. Indeed, the pension scheme is a defined benefit scheme that makes transfers between generations. Premiums and benefits from private pensions are income-dependent.

Demographic developments in GAMMA are modelled according to an overlapping generational structure. Households begin their economic lives at age twenty and can potentially live to be 99 years old. Cohort sizes from year to year are determined by the jump-off population in the base year and the age-specific rates of fertility, mortality and net immigration in the years from the base year onwards. We have taken the jump-off population from the CBS. The rest of the data are obtained from the CBS and the PEP files, as described above.

2.3 PEP and GAMMA

A final remark on the connection between the demographic and economic parts of the model concerns the perfect foresight of economic agents. Within each simulation, agent have perfect information about future events. For example, households are fully aware of future fiscal policies. The same holds true for firms and the pension sector which are also perfectly forward-looking. In each of the stochastic paths, the second-pillar pension contribution rate adjusts to reflect demographic developments in future years. To some extent, this will affect household decisions years before the developments materialize and thus there may be some bias in savings/consumption behaviour in the simulations.

The incorporation of fully-rational behaviour instead of perfect foresight would probably have seemed somewhat less ad hoc, but would have required a complete reconstructing of the model and this is clearly beyond the scope of this paper. Moreover, it is an open question whether this would change the spread of the predictive distributions to an important degree. Alho and Määtänen (2007) find, for instance, that the welfare consequences to households of ignoring aggregate mortality risk are fairly small, which suggests that behavioural economic reactions in response to aggregate demographic uncertainty may not matter that much.

3 Size and age structure of the population

It is well-known that the Netherlands, in addition to many other countries, faces an ageing population. The situation has been brought about by a combination of factors. Notably, the baby boom which accompanied the rapid expansion of the economy following the Second World War was itself followed by a “baby bust” that still continues today. Fertility rates remain persistently low, although not as low as in many other European countries. Compounding this effect was the steady decrease in mortality rates attributable to advances in life-extending technologies and improvements in overall environmental factors including diet and hygiene. It is significant that the scales of both developments in fertility and mortality were quite unexpected. Indeed the ex-post assessment of demographic projections made over the last century has exposed that systematic errors had been made by forecasters (see Keilman, Cruijsen and Alho (2007)).

It is not unreasonable to suppose that we are equally ignorant about the demographic evolution of the Netherlands in the coming years. Table 3.1 quantifies this ignorance by presenting the means and standard deviations of the distributions of the vital demographic rates and resulting life expectancies at birth for males and females taken from 359 PEP simulation runs. 359 simulations is considered a sufficient number to produce well-behaved distributions. Previous studies that coupled GAMMA and PEP relied on between 200 and 250 simulations. We have found that increasing the number of simulations above 250 does not have a significant effect on the distributional outcomes. The 359 simulations where taken from an initial run of 501 simulations, of which 37 did not solve.

The other 105 simulations were omitted due to extremely high population results. In these projections, the exponential effect of high fertility rates in the steady state resulted in total populations for the Netherlands of more than 100 million by 2205, a figure that confronts common sense notions about the physical capacity of the Netherlands. Furthermore, a strong majority of these projections featured steady-state growth rates that exceeded the marginal product of capital, indicating that the economy in each of these cases was dynamically inefficient. While dynamic inefficiency is a theoretical possibility, empirical evidence has shown that it has not occurred historically, even in countries with very high savings rates (see Abel *et al.*(1989)).

In the real world, we would expect that as population levels become so high that there would be a behavioural feedback effect from this congestion on population growth. If the growth was localized to the Netherlands, either fertility would decrease or emigration would increase.[7] If the growth was a more global phenomenon, expectations of a rise in the rate of change of future demand for output would increase desired capital investment and put upward pressure on interest rates, thereby buffering against a move towards dynamic inefficiency. Unfortunately,

[7] For example, a survey by Lee (1987) finds that estimated elasticities of fertility with respect to population densities are overwhelmingly negative.

these sorts of endogeneity are beyond the current state of the model and we chose to settle for simply omitting these 105 simulations from our sample. An alternative solution to the problem would have been to endogenize the net migration rate in a mechanical way within the demographic model in order to achieve lower net population growth rates. However this would have required assumptions that are as equally ad hoc as eliminating the extreme projections.

According to the mean estimates, by 2050 the average death rate will exceed the average birth rate, implying that the natural rate of increase will be negative.[8] However, this will be compensated for, to some degree, by an expected rise in the average net immigration rate. Note that the mean estimates of life expectancies are quite stable in contrast to the upward trend predicted by many demographers (see Lee and Carter (1992)). This is due to the more conservative projections produced by the CBS that are used for the point forecasts here. The main message of the table, though, is that this projection is subject to considerable uncertainty according to the standard deviations of the rate distributions. Taking into account the forecast errors that the PEP program mimics, some doubt is cast on whether the population of the Netherlands will increase or decrease in the coming decades as we show below.

Table 3.1 Summary statistics - demographic rates[a] and life expectancies

	2010	2020	2030	2040	2050
Birth rate					
- average	10.85	10.61	10.71	10.07	10.06
- standard deviation	0.65	1.44	2.23	2.49	2.89
Net immigration rate					
- average	0.41	0.73	1.20	1.62	1.96
- standard deviation	1.35	1.88	1.83	1.84	1.93
Death rate					
- average	8.76	9.99	11.63	13.19	13.68
- standard deviation	0.46	1.00	1.56	1.78	1.84
Life expectancy - males					
- average	78.25	78.93	79.34	79.57	79.76
- standard deviation	0.59	1.32	2.09	2.70	3.38
Life expectancy - females					
- average	82.05	82.53	82.76	82.72	82.58
- standard deviation	0.58	1.29	2.04	2.67	3.27

[a] Per thousand individuals.

[8] In fact, all the demographic rates are cohort-specific. Here we report them averaged over the entire population. As explained in section 2, PEP applies stochastic shocks to rates of mortality and net immigration for all cohorts and rates of fertility for female cohorts aged 15 to 49. Instead of the average fertility rate, here we report the *birth* rate (total births/total population) in order to make a transparent comparison with the other two rates.

Viewed in isolation, it is difficult to say how the predictive distributions of each of these demographic rates will influence the make-up of the population in the years ahead. For example, we may want to know whether a misestimation of future fertility rates would be more consequential to the forecast than a misestimation of mortality rates. However, the relative importance of variations in fertility, mortality and immigration rates on the demographic structure are difficult to disentangle. In the case of the present situation, it is tempting to characterize the ageing of the population as a consequence mainly of past changes in fertility: either the baby boom or the subsequent bust. However, the longevity of the baby-boomers is an essential ingredient in the approaching demographic imbalance. The interdependence of fertility rates and mortality rates on the demographic structure applies equally to projections into the future. Any attempt to commit ourselves to a thought experiment that aims at isolating the effects of one of the rates is flawed since it would still require some ad hoc assumption to be made about the other two.

We leave this matter aside to concentrate on the predictive distribution of demographic structures generated by these rates. Figure 3.1 illustrates by showing our ‘fan chart’ of the population size: a time series of population distributions of the Netherlands for the years 2008 to 2058. The line labelled ‘base scenario’ denotes the point estimate (shock-free) forecast. The lines labelled 90%, 80%, 50%, 20% and 10% are trend lines indicating the ninetieth, eightieth, fiftieth, twentieth and tenth percentiles of the forecasts. They do not correspond to single paths of the PEP simulations; rather the range between the lines 90% and 10% may be interpreted as an 80% confidence region for the population forecast for any given year. Likewise, the region between the lines 80% and 20% corresponds to a 60% confidence region. The 50% line corresponds to the median forecast.

As one can see, the median and baseline forecasts deviate only little and the predictive distribution is quite symmetric.[9] However, even this slight difference illustrates the way in which stochastic simulations enhance the analysis. The interpretation of the deterministic (point forecast) projection is that, over the next fifty years, the population will increase slightly. Conversely, the interpretation of the stochastic projections is that it is actually just about an even bet whether the total population will increase or decrease over that time.

For our purposes, a more informative demographic statistic than the total population is the elderly dependency ratio, the ratio of the number of retirees to the number of potential workers. In the Netherlands in 2007, the elderly dependency ratio is approximately 25% and is expected to rise in the future due to the factors discussed above. Figure 3.2 shows the time series of stochastic dependency ratios produced by the PEP program.[10] It can be seen that the dependency ratio will undoubtedly increase, however the range of uncertainty increases considerably as time goes on.

[9] See the values for skewness in the summary statistics Table A.1 in the appendix.

[10] Here the ratio is calculated as the number of individuals between 65 and 99 years-old divided by the number of individuals between 20 and 64 years-old.

Figure 3.1 Stochastic forecasts of the population size in 2008-2058

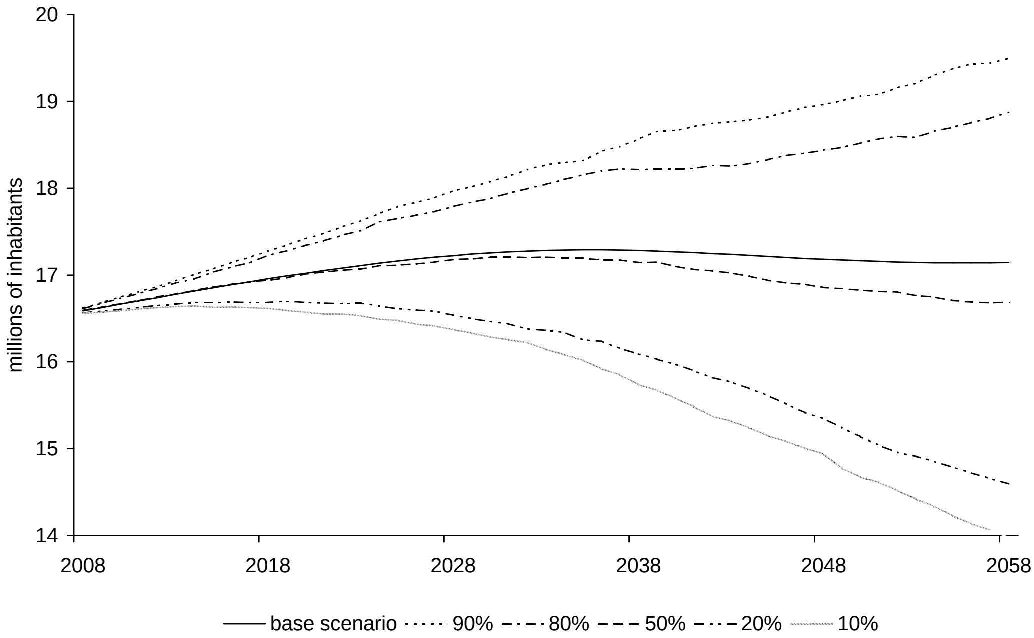


Figure 3.2 Stochastic forecasts of the elderly dependency ratio 2008-2058

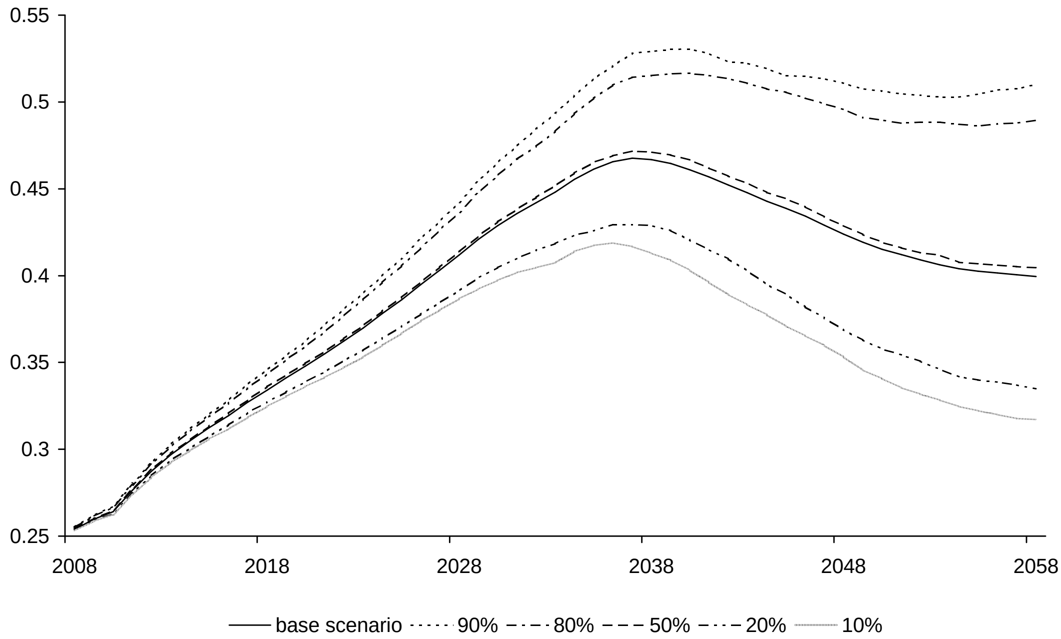
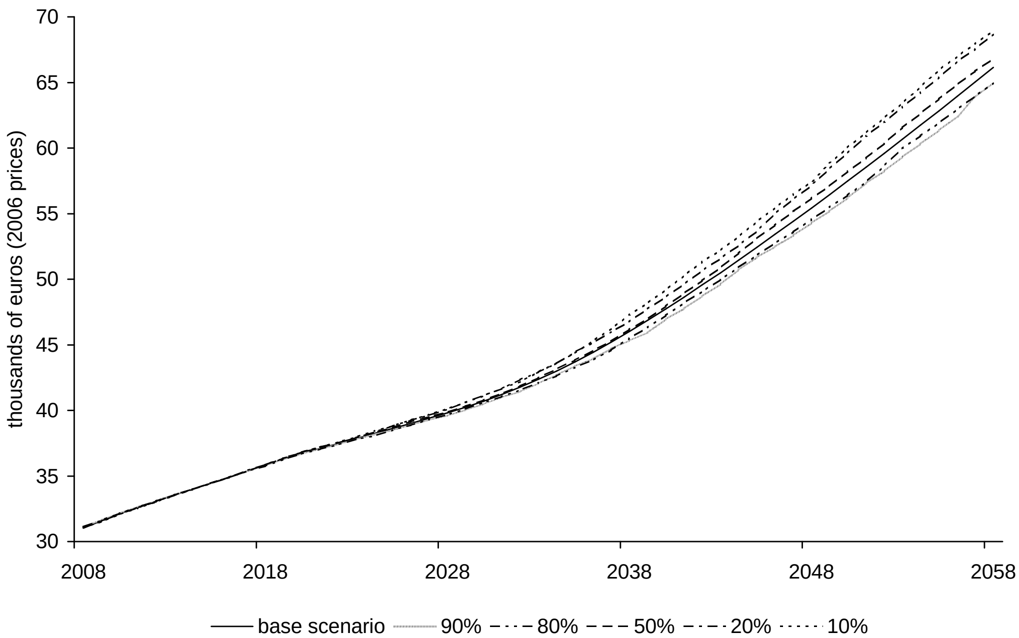


Figure 3.3 demonstrates how combining the PEP simulations with GAMMA results in a probability distribution of macroeconomic outcomes. Increases in (non-stochastic) labour productivity will cause real domestic production to increase by a significant degree over the next fifty years. As with the demographic projections, the uncertainty regarding the estimate increases as time progresses. However, the uncertainty concerning the GDP projections is less than the uncertainty concerning the population projections. For example, the standard deviation of the per capita GDP distribution in 2050 is 5.8% of the mean, while the standard deviation of the dependency ratio distribution is 15.4% of the mean. Indeed, since the relevant statistic here is GDP *per capita*, the uncertainty of the forecast is largely a reflection of the variance in the size of the workforce (those aged between 20 and 64 years) relative to the variance in the size of the population, two variables that are quite highly correlated.

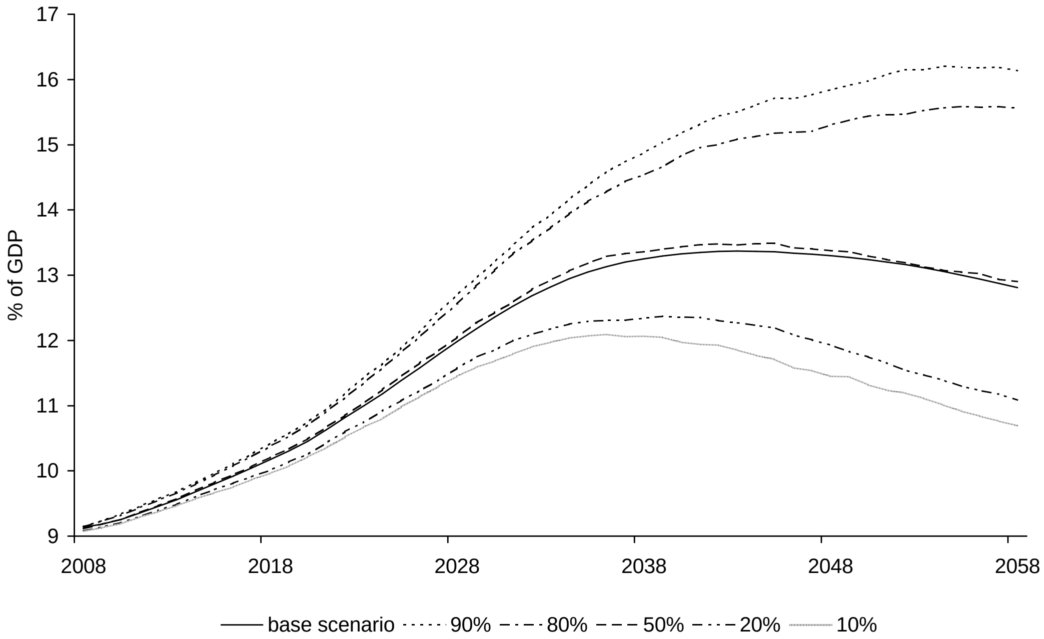
Figure 3.3 Stochastic forecasts of real GDP per capita 2008-2058



4 Public expenditures and revenues

We now direct our attention to the main focus of the article: public finances. The expected increase in the elderly dependency ratio will put pressure on public finances in two directions. First, a large portion of the government budget is allocated to demographically sensitive expenditure categories such as health care and social security, which includes public pensions and disability transfers. It turns out that, under even the most optimistic set of assumptions, ageing will drive up public expenditures if the cohort profile of these outlays remains unaltered. Second, taxes on labour income comprise a substantial share of government income. Thus for a given set of tax rates, a relative shrinkage in the tax base (in this case the proportion of individuals in the population of working age) decreases revenues as a proportion of GDP. Viewed another way, for given revenue requirements, the direct burden of taxation will be greater for each worker as will the aggregate excess burden of taxation. We will return to the issue of the distortionary effects of taxes in section 5. In this section it is assumed that the tax-benefit system remains as it is in 2007.

Figure 4.1 Stochastic forecasts of public health care expenditures 2008-2058



Figures 4.1 and 4.2 illustrate how public expenditures on health care and public pensions will develop based on the stochastic demographic scenarios produced by PEP. In each instance, demographic developments are sure to increase spending both in absolute terms and as percentages of GDP in the coming decades by a significant degree. Additionally, the simulated forecast error of the projections is substantial: the standard deviations of the distributions in 2050 are 13.5% and 15.5% of the means for the GDP shares of health care and public pension expenditures respectively.

Figure 4.2 Stochastic forecasts of public pension expenditures 2008-2058

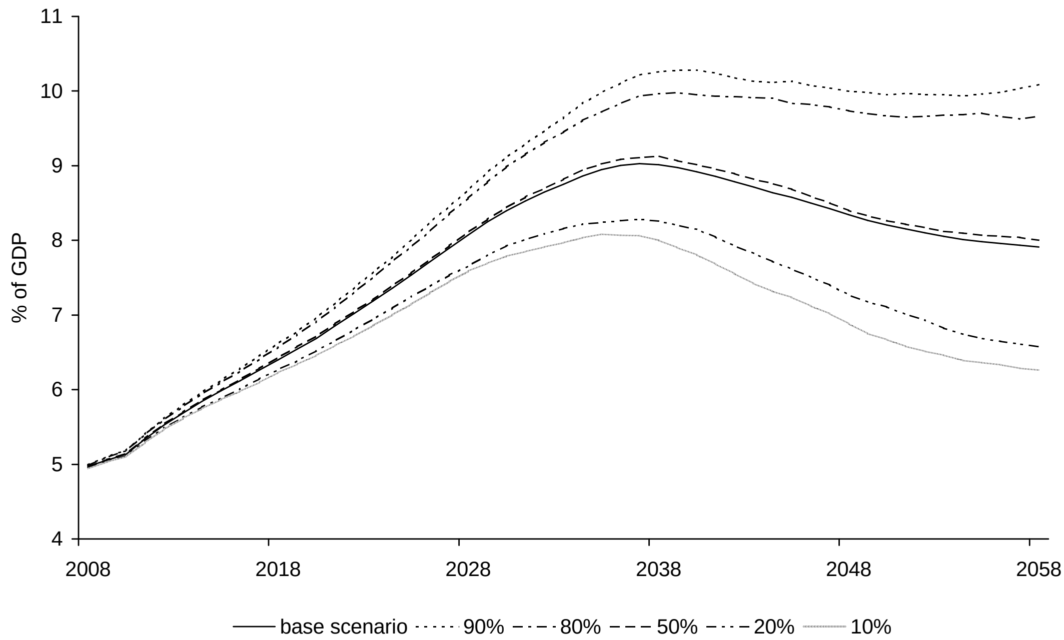


Figure 4.3 illustrates the distribution of stochastic overall public expenditure projections in percentages of GDP. Assuming that institutional arrangements remain unaltered, public expenditure is sure to rise, with the 80% confidence region estimated at approximately between 47.2% and 56.3% of GDP in 2058. This considerable range is due to the large portion of public expenditures attributable to demographically sensitive items. For example, in 2006, health care expenditures comprised approximately 19.3% of the government budget while public pension expenditure comprised approximately 10.4% of the budget. According to the baseline demographic projection, these shares will increase to 24.9% and 15.4% respectively in 2058.

Unlike the second-pillar occupational pension system in the Netherlands, public pensions are an unfunded pay-as-you-go (PAYG) system: benefits to retirees are financed with the concurrent contributions of workers. The health care system is also essentially a PAYG system. Since the size of the contribution base in future years is also influenced by demographic uncertainty, the public pension and health care systems suffer from 'double jeopardy': uncertainty with respect to both expenditures and revenues.

Figure 4.3 Stochastic forecasts of primary public expenditures 2008-2058

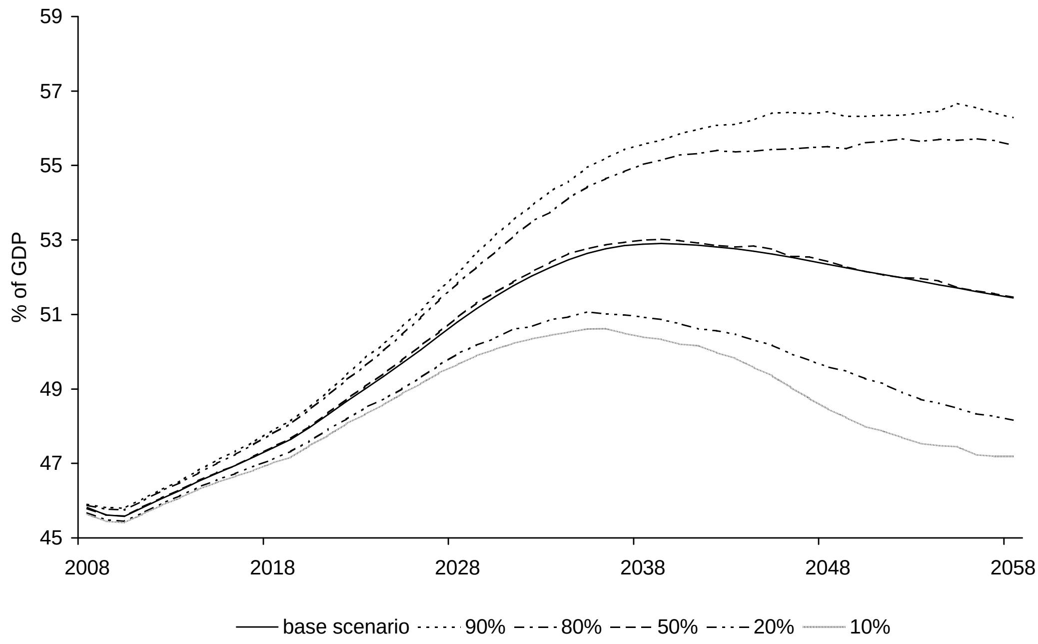


Figure 4.4 Stochastic forecasts of government revenues 2008-2058

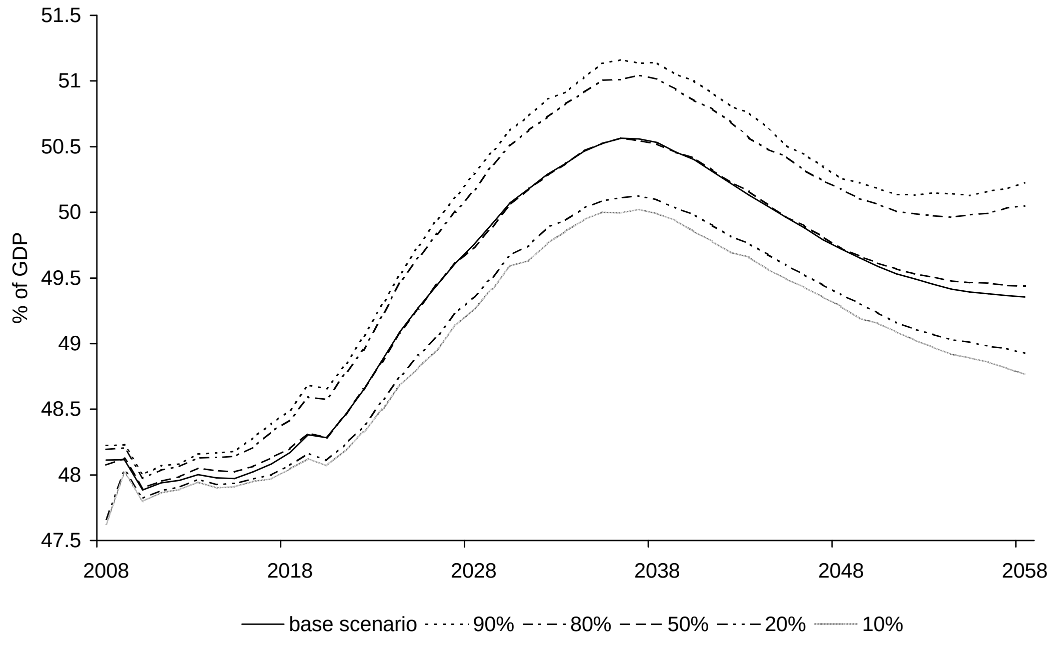


Figure 4.4 illustrates the effects of demographic uncertainty on public revenues. Inspection of the figure reveals how public revenues are driven by demographic developments, in particular fertility and immigration rates. In the simulations, the shocks to the growth rates begin in 2008, but only the shocks to the immigration rates are relevant immediately. The impact of uncertainty about fertility only becomes significant after about 2028 when the first cohort of uncertain size due to fertility rate shocks reaches working age. There is less variation in expected revenues than expected expenditures: the standard deviation is 0.83% of the mean estimate in 2050 for revenues compared to the standard deviation of 6.0% of the mean estimate for expenditures. One could object that these projections assume that future labour participation rates within each stochastic simulation are known with certainty. Accounting for this added source of uncertainty would indeed increase the forecast error of the revenue projections.

5 Three measures for sustainability

The simulation results presented so far have assumed that government policies with respect to tax rates and public spending will remain indefinitely as they are in 2007. This was done to address the following question: accounting for the effects of demographic uncertainty on public finances, what is the probability that present fiscal arrangements are sustainable? In order for fiscal arrangements to be considered sustainable, the present value of all future revenues must equal or exceed the present value of all future expenditures plus the presently existing debt. An equivalent condition is that the long-run growth rate of the government's primary deficit be less than the long-run growth rate of GDP.

Figure 5.1 Stochastic forecasts of the primary fiscal deficit with unchanged policies 2008-2058

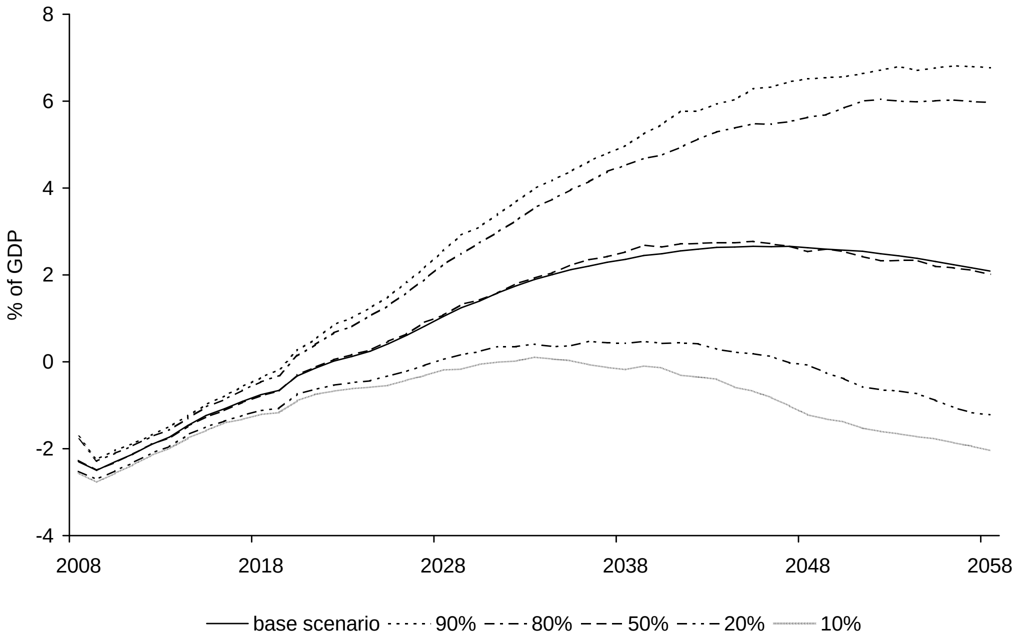
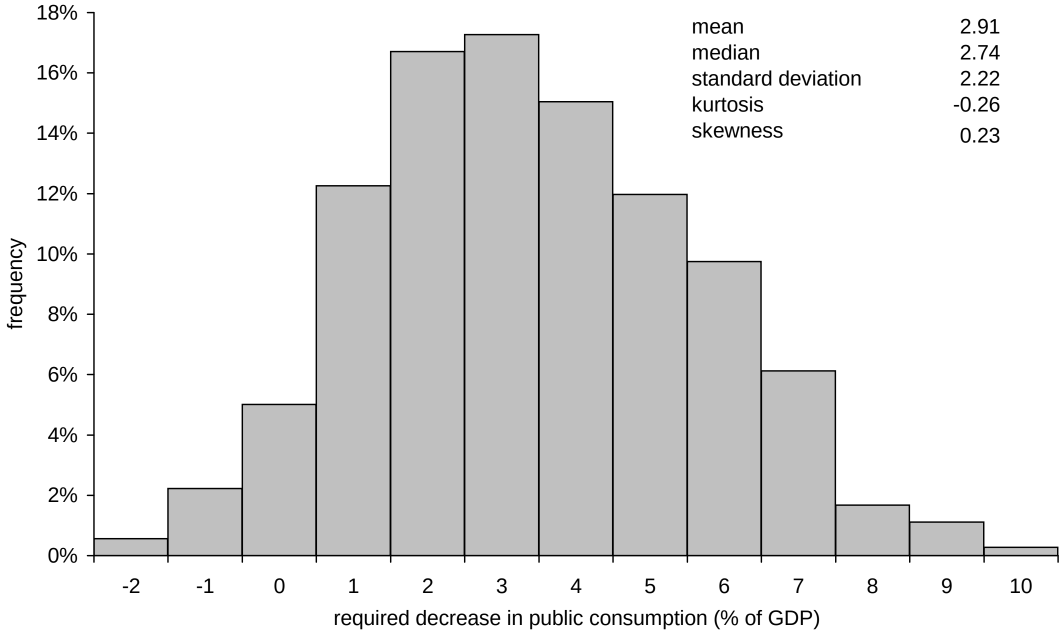


Figure 5.1 illustrates the development of the primary deficit expressed as a percentage of GDP based on the stochastic simulations. Presently, the government budget is in a surplus position. However, as public expenditure increases relative to revenues, the fiscal balance will deteriorate over time. According to the baseline projection, the long-run primary deficit will level off at over 2% of GDP. The probabilistic bounds of the simulations indicate that by 2058, in almost 80% of the projections, the primary deficit to GDP ratio will reach a steady-state level that is positive. Thus, there is approximately only a 20% chance that the primary surplus will remain positive in the long run in the current policy environment.

How can we measure the unsustainability of public finances? One way is simply to calculate the immediate and permanent reduction in annual public consumption as a percentage of GDP that would set public finances on a sustainable path. This is the measure developed by Blanchard *et al.* (1990) that ultimately stabilizes the debt to GDP ratio. Let us denote this measure as the expenditure gap. Figure 5.2 presents the outcomes for the expenditure gap for the stochastic simulations as a frequency distribution.

Figure 5.2 Frequency distribution of the expenditure gap



The mean of the expenditure gap distribution is 2.9% of GDP. Hence, decreasing public consumption by 2.9% of GDP (6.3% of primary government expenditure in 2007) will only sustain the budget with 50% probability. This estimate compares with the expenditure gap of 2.7% of GDP in the baseline scenario.[11] The 60% confidence interval for the distribution of the expenditure gap lies between 1.0% and 4.7% of GDP and the 80% confidence interval lies between .2% and 5.8% of GDP. The probability that the expenditure gap is negative, i.e. that there is no sustainability problem, is less than 10%.

An alternative measure of the unsustainability of public finances is the permanent one-time increase in tax rates that sustains the budget. Figures 5.3 and 5.4 illustrate the distribution of the required increases for two of the tax rates included in GAMMA: the consumption tax rate[12] and the labour income tax rate respectively. Analogous to the expenditure gap, we will call these the consumption tax gap and the labour income tax gap. The two tax measures are different from the expenditure gap in that they stabilize the tax rate (tax smoothing[13]), not tax revenues. Hence, the tax measures do not necessarily imply a time-invariant change of the tax revenues to GDP ratio.

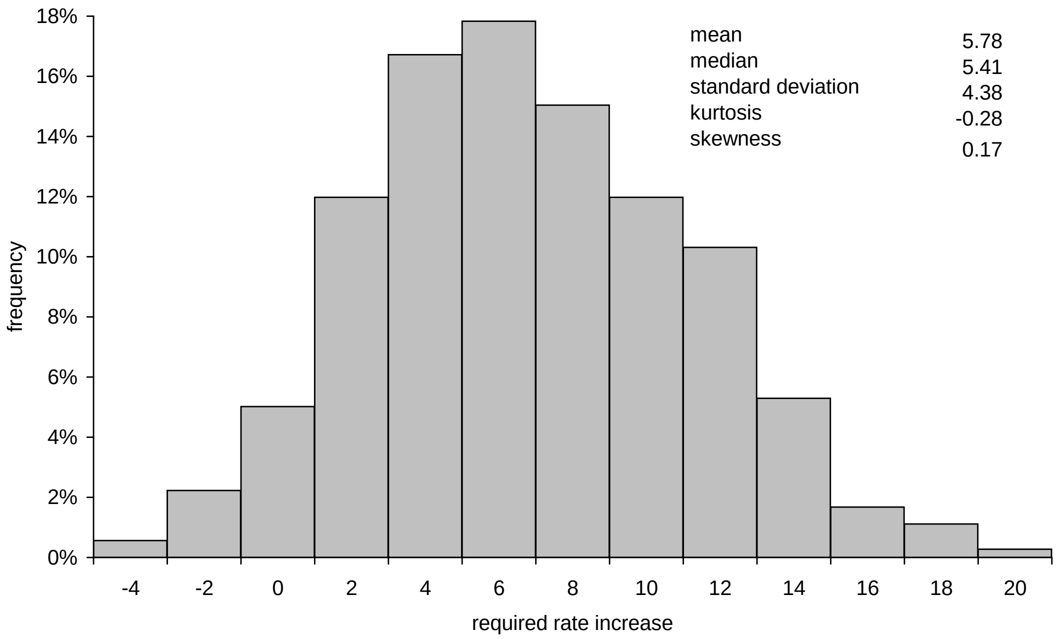
[11] The expenditure gap as reported in Van Ewijk *et al.* (2006) was 2.6% of GDP. There is a slight difference due to the fact that the CBS baseline population projection used in that study can only be approximated within the PEP program.

[12] The consumption tax is not just the V.A.T. It is comprised of all indirect taxes levied on consumers.

[13] Under some conditions, tax smoothing policies may be considered more efficient. See Armstrong *et al.* (2007) for a discussion of this issue in the context of the GAMMA model.

The mean rate increase for the consumption tax is 5.8% points above the baseline level of 26.4%. The 80% and 60% confidence intervals for the consumption tax gap are .4%points to 11.5% points and 2.0% points to 9.6% points respectively. The mean rate increase for the labour income tax is 8.9% from a baseline level of 29.1%.[14] The 80% and 60% confidence intervals for the labour income tax gap are .6% points to 18.2% points and 2.9% points to 14.5% points respectively.

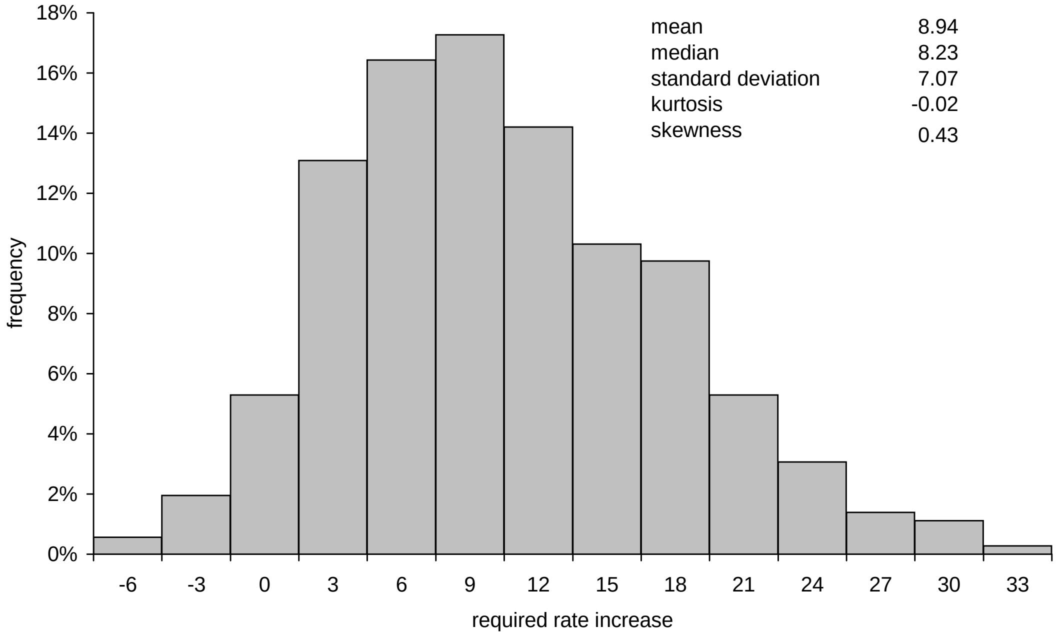
Figure 5.3 Frequency distribution of the consumption tax gap



An important difference between Figures 5.3 and 5.4 is the skewness of the frequency distributions. Indeed, the frequency distribution of the labour income tax gap is far more skewed than that of the consumption tax gap. In this respect, the distribution of the labour income tax gap also differs importantly from the distribution of the expenditure gap in Figure 5.2. The reason is that tax revenues increase less than proportionally with the tax rate. Hence, the more distortionary the tax, the more skewed to the right will be the predictive distribution of the tax rate. The consumption tax has a fairly broad base since it taxes all individuals regardless of whether they work or not and so it is relatively non-distortionary. The labour income tax, however, cannot tax retirees, so it imposes a greater distortion on the tax base.

[14] The estimate of 8.9% differs from the mean required increase of 13.4% points reported in Armstrong *et al.* (2007) due to the differing assumptions on the development of the population in the baseline projection.

Figure 5.4 Frequency distribution of the labour income tax gap



This can be illustrated by performing a rule of thumb test for the statistical significance of skewness. Let S_k be the skewness statistic for a sample distribution and N be the sample size. If $-2 < S_k / \sqrt{6/N} < 2$, then the skewness of the data generating process is not significantly different from zero. In the case of the consumption tax increase, $S_k / \sqrt{6/N} = 1.31$ and in the case of the labour income tax increase, $S_k / \sqrt{6/N} = 3.37$, so it may be concluded that the latter distribution is significantly skewed while the former is not.

6 Concluding Remarks

The large influence of the population development on public expenditures underscores the need to account for demographic uncertainty when making fiscal projections. In general, two approaches can be followed: scenario analysis, which more or less is the standard, or stochastic simulation analysis. Compared with scenario analysis, stochastic simulation analysis is much more demanding, both in terms of time and complexity. It also offers new insights, however. It gives an indication of the shape of the predictive distribution of interesting variables – demographic, macroeconomic, fiscal – at different points in time. Hence, stochastic simulations can offer an indication about the spread, the (non-)symmetry and the mean of the distribution of different variables at different points in time.

This extra information is particularly useful in those cases in which a result relates directly to the probability criterion one wants to use. An obvious example in the analysis presented here is the decrease in the ratio of public consumption to GDP that is required to avoid the unsustainability of public finances. If one requires sustainability to hold with 50% probability, a decrease of public consumption by 2.9% of GDP suffices. However, if one requires public finances to be sustainable with 80% probability, then a much larger decrease is needed: 4.7% of GDP. And if one takes 90% as the probability criterion, the required decrease is even 5.8% of GDP. The implication of this is that the preferences of policymakers in general and in particular their aversion towards risk come to play a role in the result of the analysis. In particular, the less risk policymakers want to take that public finances may eventually turn out to be unsustainable, the more substantial are the policy reforms they have to undertake. Under some assumptions then, uncertainty combined with risk aversion may call for precautionary saving on part of the government (or, equivalently, excessive public debt reduction).[15]

Related, the analysis presented here demonstrates that current fiscal policies may turn out not to be unsustainable at all. Indeed, if future mortality rates evolve at lower levels than expected, there may actually be room for an increase in the ratio of public consumption to GDP. The value added of a stochastic simulation exercise is that the probability that such a scenario will materialize can be quantified: about 7.8% in the current analysis.

Furthermore, in case of nonlinearities, the average outcome of the stochastic simulation analysis may be different from the outcome of the most likely future projection. In the case in which public expenditures are decreased such as to avoid public finances becoming unsustainable, nonlinearities are absent. Indeed, the average of the stochastic simulations, 2.9% of GDP, is quite close to the outcome under the baseline scenario, 2.7% of GDP. In case the rate of labour income taxation is increased to ensure sustainability, nonlinearities are important,

[15] See Armstrong *et al.* (2007).

though. The baseline projection calculates that this tax rate should be increased by 7.8% points. According to stochastic simulation analysis, this tax rate increase can be higher and lower, but on average the increase is 8.9% points.

Overall, our analysis concludes that the uncertainties and their economic impacts are huge. Still we feel that the role of uncertainty may be underestimated since our analysis does not consider economic uncertainty. The risks posed by uncertainty in productivity growth, rates of return and participation rates, among others, should ideally be accounted for. Indeed, the argument has been made that the consequences of economic uncertainty outweigh those of demographic uncertainty, at least with respect to social welfare (Bonenkamp and Van de Ven (2006)). Hence, our results may actually underestimate the role of uncertainty in general. Furthermore the model itself is subject to uncertainty; the values of model parameters are not more than estimates of their true values. In addition, the analysis does not consider cataclysmic events, like pandemics or a third world war. On the other hand, the analysis does not identify the effects of economic developments on demographic factors either, which may lead us to overestimate the role of uncertainty.

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Appendix: summary statistics

Table 6.1 Summary statistics - total population (thousands of individuals)

	2010	2020	2030	2040	2050
Mean	16,667	17,009	17,193	17,115	16,874
Median	16,667	17,009	17,205	17,098	16,828
Standard deviation	60.02	325.33	720.34	1204.38	1719.57
Kurtosis	– 0.31	– 0.14	0.13	0.16	– 0.03
Skewness	0.00	– 0.05	0.25	0.31	0.21

Table 6.2 Summary statistics - elderly dependency ratio

	2010	2020	2030	2040	2050
Mean	0.26	0.35	0.43	0.47	0.42
Median	0.26	0.35	0.43	0.47	0.42
Standard deviation	0.00	0.01	0.03	0.05	0.07
Kurtosis	0.51	0.26	0.50	– 0.11	– 0.15
Skewness	– 0.28	– 0.16	– 0.20	– 0.06	0.03

Table 6.3 Summary statistics - real gross domestic product per capita (thousands of euros)

	2010	2020	2030	2040	2050
Mean	32.12	36.76	40.82	48.07	58.22
Median	32.12	36.74	40.84	48.01	58.08
Standard deviation	0.12	0.44	1.21	2.27	3.39
Kurtosis	– 0.20	0.71	0.12	– 0.01	0.26
Skewness	– 0.03	– 0.10	– 0.06	0.06	0.39

Table 6.4 Summary statistics - primary public expenditures (% of GDP)

	2010	2020	2030	2040	2050
Mean	45.59	48.01	51.57	53.04	52.32
Median	45.59	47.99	51.59	52.98	52.15
Standard deviation	0.15	0.43	1.24	2.27	3.13
Kurtosis	– 0.16	0.24	0.61	0.16	– 0.31
Skewness	0.13	0.02	0.04	0.13	0.02

Table 6.5 Summary statistics - public health care expenditures (% of GDP)

	2010	2020	2030	2040	2050
Mean	10.49	10.49	12.45	13.53	13.54
Median	10.49	10.49	12.43	13.44	13.30
Standard deviation	0.22	0.22	0.62	1.24	1.82
Kurtosis	0.08	0.08	0.44	0.00	– 0.17
Skewness	– 0.01	– 0.01	0.03	0.25	0.30

Table 6.6 Summary statistics - public pension expenditures (% of GDP)

	2010	2020	2030	2040	2050
Mean	5.15	6.71	8.45	9.02	8.34
Median	5.14	6.72	8.44	9.02	8.26
Standard deviation	0.04	0.20	0.54	0.96	1.29
Kurtosis	0.91	0.21	0.54	– 0.08	– 0.17
Skewness	– 0.05	– 0.17	– 0.19	– 0.06	– 0.01

Table 6.7 Summary statistics - government revenues (% of GDP)

	2010	2020	2030	2040	2050
Mean	47.90	48.33	50.08	50.42	49.65
Median	47.90	48.28	50.06	50.42	49.61
Standard deviation	0.08	0.23	0.42	0.43	0.41
Kurtosis	– 0.07	0.40	– 0.13	– 0.15	0.19
Skewness	0.13	0.78	0.17	0.04	0.33

Table 6.8 Summary statistics - primary fiscal deficit (% of GDP)

	2010	2020	2030	2040	2050
Mean	– 2.31	– 0.32	1.49	2.62	2.68
Median	– 2.32	– 0.30	1.42	2.65	2.54
Standard deviation	0.21	0.45	1.32	2.31	3.07
Kurtosis	– 0.11	0.44	0.49	0.13	– 0.27
Skewness	– 0.09	– 0.10	0.12	0.19	0.07