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The Impact of Population Ageing on the Czech Economy

Jan Babecký and Kamil Dybczak*

Abstract

The Czech Republic is facing a population ageing phenomenon. In addition, its demographic structure is expected to change dramatically over the next 50 years. We apply a stylised overlapping generation model in order to analyse the potential effects of the expected demographic changes on aggregate economic performance taking into account alternative fiscal policy set-ups. We provide a rough estimate of the amendments necessary on the revenue and expenditure sides in order to keep the current system financially balanced. We also discuss the implications for the development of other economic variables. In particular, we separately simulate future developments in the cases of adjustment in either the contribution rate or the value of public benefit. In addition, we demonstrate that parametric changes, such as an increase in the statutory retirement age, cannot eliminate the impact of the deterioration in the demographic structure on the course of the economy.

JEL Codes: E27, J11, H55.
Keywords: Population ageing, public pension systems, social security.

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Nontechnical Summary

In the coming fifty years the Czech Republic is expected to face sizeable changes in the age structure of its population. According to the demographic projection issued by Eurostat (EUROPOP (2008)), the share of people over 60 in the total population, which is currently 24 per cent, is expected to increase to 38 per cent by the year 2050. On the contrary, the share of people aged 20 to 40 should decrease from 40 per cent in 2008 to 29 per cent in 2050. Evidently, such a substantial demographic change might have a significant impact on the functioning of the Czech economy.

The objective of this study is to assess the impact of the expected demographic changes on the development of the Czech economy, given alternative scenarios for government budget policies and the statutory retirement age. Since the settings of government budget policies affect the behaviour of both households and firms, they may also change the overall impact of the expected demographic changes on the economy. In this study, we consider two limiting cases of public financing. At one extreme, we assume that the government decides to maintain the ratio of social security benefits to the wage rate at the current level, i.e. the government preserves the current version of the defined benefit (DB) pension system. In consequence, the contribution rate is adjusted in order to finance public expenditures, which are expected to increase along with population ageing. As the opposite limiting case, we assume that the current level of the contribution rate remains fixed. However, the generosity of social security benefits is adjusted to ensure a balance between public revenues and expenditures. This scenario corresponds to the so-called defined contribution (DC) pension scheme, under which the government reduces the use of the DB principle of social security and motivates individuals to accumulate personal savings.

Using a computable overlapping generation model calibrated to fit the 2006 data, we make projections of the key macroeconomic variables up to 2050. We find that depending on the type of public budget closure rule and the statutory retirement age, the simulation outcomes may differ substantially. In addition, the projections are affected by the way the real interest rate is determined, e.g. on domestic versus international capital markets.

Combining alternative assumptions for the fiscal policy set-up, the statutory retirement age and real interest rate determination, our simulations show that the performance of the Czech economy is primarily affected by the expected demographic changes. Even under the assumption of a relatively high effective retirement age, a change in the demographic structure still has a significant impact on overall macroeconomic development. The model outcomes illustrate that the impact of population ageing seems to be higher when one assumes the current DB pension scheme, where the generosity of the pension system is preserved and individuals are not motivated to work and save more when young. On the contrary, the impact of ageing is reduced when one assumes a DC pension scheme, where the generosity of public pension schemes is reduced and subsequently individuals are motivated to increase their labour supply and individual savings for the later stage of life. Thus, our results are in line with the current practice in many European countries that have reformed their pension schemes, i.e. the role of DC schemes has been promoted and the significance of DB schemes suppressed.[1]

[1] A comprehensive overview of European pension schemes' characteristics, recently introduced reforms and their expected impact on European economies is provided by EPC-AWG (2009).

1. Introduction

Over the last five decades the world's population has changed significantly. Both the size and the structure of the population have evolved unprecedentedly in developed as well as in developing countries. Still, the population ageing phenomenon is characteristic mainly of developed countries, where fertility rates have fallen remarkably and a significant increase in longevity has been gained at the same time. Concerning the European countries, life expectancy has been growing constantly over recent years mainly thanks to improvements in living standards and health care services. In addition, work has become less physically demanding. As a whole, life expectancy at birth rose from 73.5 to 76.1 for men and from 72.7 to 82.1 for women between 1960 and 2008. The deterioration in the age structure in Europe was further deepened by a drop in the fertility rate from 2.7 in 1960 to 1.5 in 2008. As a consequence, the age structure of the European population has changed significantly, i.e. the share of elderly people in society has increased. Moreover, the demographic changes are expected to continue in the coming years.[2] Thus, in 2060 the average life expectancy at birth is expected to be 84.6 and 89.1 for men and women respectively. The fertility rate is anticipated to stabilise close to the current level of 1.5 or to improve slightly to 1.7 over the same time horizon. The total population in the EU-27 is expected to increase by 2.1% between 2008 and 2060, while significant differences at the country level are expected.[3]

The above-mentioned factors have been acting in the Czech Republic as well. In 1960, life expectancy at birth was 67.5 for men and 67.4 for women. Currently, the same indicator is 73.9 and 80.2 for men and women respectively. The fertility rate has fallen from 2.1 in 1960 to its current value of 1.3. As a result, the population structure of the Czech Republic has been changing over time. Figure 1.1 demonstrates that between 1960 and 1990 Czech society was characterised by a relatively high ratio of economically active individuals. The share of people aged 20 to 40 in the total population was relatively high, due above all to large post-war generations. Following the demographic trends, the proportion of persons aged 20–40 has begun to fall, while the importance of the 41–60 and 61–80 age groups has increased.

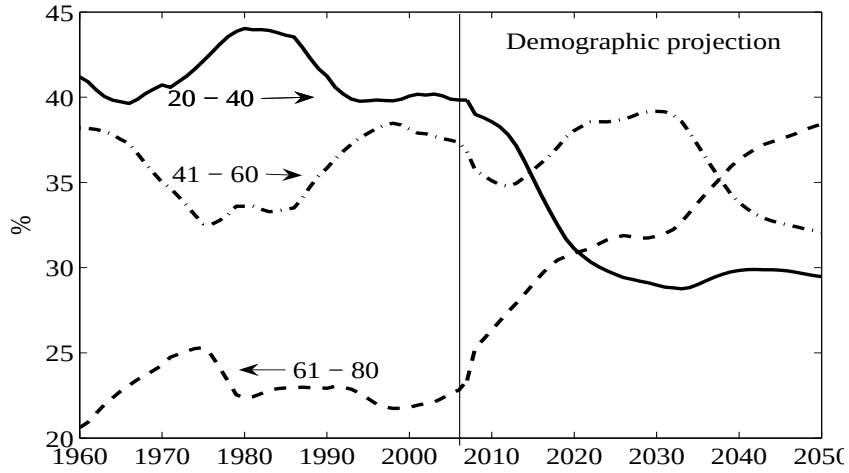
Overall, according to Eurostat's EUROPOP (2008) demographic projection, the main characteristics of the demographic transition of the Czech Republic are similar to those of other European countries. In particular, over the next fifty years, life expectancy at birth is expected to increase by 6 years for both men and women. Nevertheless, the increase in the number of persons aged 61 years or over and the decrease in the proportion of younger persons are expected to be even more pronounced in the case of the Czech Republic. Based on the EUROPOP (2008) demographic projection one can say that the age structure of the population is expected to be almost inverted in 2050 compared to the situation in 1960, as illustrated in Figure 1.1. On top of that, the Czech population is expected to decrease by 8% by 2050.

There is no doubt that the gains achieved in terms of life expectancy in the recent past are desirable. Still, they seem to have important implications for the economy and the country as a whole, i.e. it is evident that the size and structure of the population decisively affect current as well as future economic developments. The most important direct implications of an ageing population are related to labour market developments. First, the number of people capable of

[2] The EUROPOP (2008) population projection applied in this study was produced by Eurostat; for details see Giannakouris (2008).

[3] An extensive description of the past and current demographic trends, including the related implications for the European economy, is provided by EPC-AWG (2008). The overall world demographic perspective is discussed by the Global Economic Outlook, IMF (2004).

Figure 1.1: Demographic Development in the Czech Republic Between 1960 and 2050



Source: Eurostat, EUROPOP (2008).

working decreases, i.e. labour supply shrinks. Second, as argued for example by Kotlikoff and Wise (1989), Miles (1999) and Börsch-Supan and Essig (2003), individual productivity is age dependent, i.e. individual productivity is rising for young individuals as they accumulate experience and decreasing for old individuals as they become less flexible and less efficient. As a consequence, the age structure of society determines both the size and quality of the labour force, i.e. the effective amount of labour.

In addition, fiscal policy is affected by population ageing. As the labour force shrinks, an important part of fiscal revenues falls. Moreover, public pensions and other age-related expenditures will rise due to the increasing number of economically inactive people. Since public expenditures have to be financed from public revenues, the government will have to change its fiscal policy set-up to collect enough funds. Adjusting either revenues or expenditures will definitely alter the relative prices of labour, capital, consumption and savings. In what follows, the adjustment of government policy parameters will affect the behaviour of households and firms. By the same token, the welfare costs of the demographic transition can be significantly affected by the fiscal reaction, for example by the set-up of the pension system. In a nutshell, the overall effect of the demographic transition can be altered by the government's reaction and the subsequent reaction of households and firms to the new fiscal policy parameters.

But would the envisaged changes significantly affect the future course of the economy? And what could be the implications of the current and expected demographic changes for inhabitants?[4] Previous population-ageing research in the case of the Czech Republic analysed the problem using more or less advanced trend projections of the current situation (see, for example, Bezděk et al. (2003); Dybczak (2006)). These analyses were based on the simplifying assumption that economic agents do not react to the changes in the economic environment.

[4] It is often stressed that the uncertainty associated with long-term projections is rather high. Still, alternative population projections provided by different institutions confirm unanimously that the proportion of older people in the population will rise significantly in the future. Nevertheless, the size of the projected changes varies by institution.

Those analyses provided us with gross estimates of the future public indebtedness and intergenerational imbalance resulting from the current fiscal policy settings. Yet in reality, fiscal policy is not a one-off event with one-off outcomes; fiscal policy evolves over time and leads to a time sequence of economic reactions.[5] Thus, our intention is to offer an improved analysis of the macroeconomic effects of the envisaged demographic changes in the Czech economy when alternative government policies are taken into account. As a result, our primary objective lies in developing and calibrating an overlapping generation (OLG) model of the Czech Republic.

The pioneering work on OLG models was presented by Samuelson (1958) and Diamond (1965). Since that time many improvements have been introduced into the OLG framework. Moreover, the scope of OLG analysis has changed. The seminal work by Auerbach and Kotlikoff (1989) explored the impact of public finances using this type of model. The authors built a dynamic general equilibrium model which introduced 55 age-specific generations following the life-cycle hypothesis. This model gave a different view of alternative fiscal policies compared to the standard Keynesian approach. Following the Auerbach and Kotlikoff tradition the current OLG models are used mainly to address demographic changes and the dynamic implications of fiscal policy on economic growth. OLG models have become a prominent tool for analysing ageing-related issues.

The scope of the ageing-related research has rapidly expanded. In particular, as soon as changes in the population structure began to affect the revenue and expenditure sides of public budgets, attention was focused on assessing the effects of upcoming demographic changes on the sustainability of public pension and social security systems, i.e. on the impact of population ageing on public finances.

Recently, a wide strand of literature has concentrated on the implications of expected population changes on financial markets, international capital flows and financial stability. As proposed above, in an effort to stabilise public budgets, national governments are expected to reduce the generosity of social security and public pension programmes. As a consequence, rational individuals will adjust their behaviour to ensure a certain level of consumption as they get older. Afterwards, as capital per unit of effective labour changes, the real interest rate adjusts until a new equilibrium is reached. Generally, as the population becomes older real interest rates are expected to fall. It has further been suggested, for example by McMorrow and Röger (2003), Poterba (2004) and Miles (2002), that the envisaged demographic changes may affect not only the absolute size of individuals' portfolios, but also their structure. In addition, the structure of portfolios may alter, assuming that risk aversion increases with age. In particular, demand for less risky assets tends to increase as the population becomes older. Thus, the expected demographic changes potentially have important implications for the functioning of the financial markets and financial stability.[6]

Where capital markets can be characterised by a high degree of capital mobility, it is expected that different sizes and timings of demographic changes will lead to significant international capital flows. When the domestic labour force shrinks, an excess of private wealth is accumulated in the economy. As a result, a part of domestic private wealth is expected to be exported to other countries with non-synchronised demographic development. Bösch-Supan et al. (2004) and Domeij and Flodén (2004) demonstrate how shifts in the demographic structure of the

[5] Buiter (1996) compares the outcomes from generational accounts and the OLG model when discussing the role of general equilibrium mechanisms.

[6] A detailed discussion of the implications of population ageing for bank strategy and financial stability is provided by Schmitz (2007).

nation can influence the stock of net foreign assets and the current account due to massive international capital flows. Dybczak (2008) simulates the expected development of the real interest rate and capital flows in the Czech Republic up to 2060.

An overview of the relevant ageing-related literature, including the main theoretical and empirical findings, is provided by Chan (2004) or Bosworth et al. (2004).

Since the Czech Republic is among the countries which face severe population ageing in the coming years, we concentrate on quantifying the impact of the expected demographic changes on overall economic development. In this study, we do not intend to provide a precise forecast of selected macroeconomic variables over the mid- to long term. Our objective is rather to project economic trends based on the long-term demographic outlook. Moreover, we aim at assessing the amendments necessary on the revenue and expenditure sides in order to balance the public budget.

The rest of the paper is organised as follows. Section 2 describes the OLG model, which has three types of agents, namely households, firms and the government. Particular attention is paid to calibrating the OLG model to the Czech reality. Section 3 presents the simulation results and discusses the implications of the demographic changes for employment, wages, private wealth, capital stocks and flows, net foreign assets, the interest rate, the current account, production, social security benefits and the contribution rate. All the simulation outcomes are presented in the form of the difference between the population ageing scenario based on Eurostat demographic projections and a baseline scenario based on the current demographic situation. Section 4 concludes.

2. Model

In our paper we apply the Overlapping Generation Model (OLG), which originates in the seminal work by Samuelson (1958), Diamond (1965) and Auerbach and Kotlikoff (1989). In particular, we mainly follow the more recent work by Miles (2002) and Bösch-Supan et al. (2004). Since this type of model makes it possible to account for separate age groups of individuals, it is a suitable candidate for analysing the impact of demographic changes on the development of the economy. In order to simulate the role of expected demographic changes on the economy, the alternative demographic scenarios are based on Eurostat's demographic projection EUROPOP (2008).

We apply a deterministic OLG model, i.e. both aggregate and idiosyncratic risks are eliminated. As a result, individuals are highly rational and know future developments perfectly. In addition, old individuals do not transfer any part of their wealth to young generations, i.e. there is no bequest motive in the model. As discussed for example by Nardi et al. (2001) the absence of uncertainty about the date of death or of a bequest motive in the model can lead to results that do not completely capture the motives behind intertemporal saving behaviour. Still, using this type of model allows us to assess the role of demographic factors and different government policies.

2.1 Households

The key characteristic of the OLG model is an assumption that individuals live for a finite number of periods. Next, at each time point several age cohorts co-exist and the older generations

are gradually replaced by the younger ones. A household is represented by an adult individual aged between 21 and 80 years, i.e. a representative household appears in the model for 60 consecutive periods. In addition, we assume that the household's life cycle can be split into two main parts. During the first one, individuals aged between 21 and 60 years are working. Let's represent the last year spent at work by T^w.[7] Afterwards, during the second part of life, individuals are retired for the next 20 years. Finally, the age cohort of 80-year-old individuals dies. When the oldest cohort leaves the model, a new group of youngest, i.e. 21-year-old, individuals enters the model.

Since the representatives of different age cohorts differ in terms of the amount of hours worked, the accumulated value of their private wealth etc., it follows that people behave differently depending on their age. In other words, all the heterogeneity which comes out of the model is based on the different behaviour of particular age cohorts. On the other hand, we assume that the individuals within particular age cohorts are identical.

The individuals make their decisions taking into account all available information. They choose the path of consumption, number of hours worked and other individual variables through the life cycle so that they maximise the present value of lifetime utility. The above-described household bloc of the model can be formalised as follows:

$$\max_{(c_t^1,\ldots,c_{t+59}^{60},l_t^1,\ldots,l_{t+59}^{60})} \left(\frac{1}{1-\frac{1}{\gamma}} \sum_{s=1}^{60} \left(\frac{1}{1+\theta} \right)^{s-1} \left(u_{t+s-1}^s \right)^{1-\frac{1}{\gamma}} \right) \tag{2.1}$$

s.t.

$$\begin{aligned}
u_t^s(c_t^s, l_t^s) &= (c_t^{s\,1-\frac{1}{\rho}} + \alpha \cdot l_t^{s\,1-\frac{1}{\rho}})^{\frac{1}{1-\frac{1}{\rho}}}, && s = 1,\ldots,60 && (2.2)\\
a_{t+1}^{s+1} &= (1-\tau_t^y) w_t \xi_t^s n_t^s + (1+(1-\tau_t^y) r_t) a_t^s - c_t^s, && && (2.3)\\
& && s = 1,\ldots,T^w && (2.4)\\
a_{t+1}^{s+1} &= b_t + (1+(1-\tau_t^y) r_t) a_t^s - c_t^s, && s = T^w+1,\ldots,60 && (2.5)\\
a_t^1 &= 0, && && (2.6)\\
a_t^{61} &= 0. && && (2.7)
\end{aligned}$$

where variables c_t^s and l_t^s represent individual consumption and the proportion of disposable time devoted to leisure of an individual aged s in period t. Since the total disposable time can be normalised to one, l_t^s can be expressed as $l_t^s = 1 - n_t^s$, where n_t^s characterises the labour supply of the individual aged s in period t. Working individuals receive income which depends on the amount of their effective labour supply $\xi_t^s\ n_t^s$ and the value of the assets they have at their disposal a_t^s. Parameter ξ_t^s is the age profile of labour productivity over the life cycle. This parameter reflects both changing individual labour productivity over the life cycle and aggregate growth in technological progress.[8] Economically inactive individuals, i.e. retirees, receive income in the form of public subsidies b_t and returns from their lifelong savings. The price of labour is given by the wage rate w_t and the price of capital is determined by the real interest rate r_t. Labour earnings and capital returns are taxed at the effective flat contribution rate τ_t^y.

[7] In all of the simulations provided later on, we assume that the government can affect the value of T^w. In particular, we assume that the government increases the retirement age by 1 year every 5 years until it reaches the value of 65 years.

[8] The role of the index of labour productivity for the model outcomes is discussed in subsection 2.5 and for example by Martins et al. (2005).

Individual preferences are described by the following set of parameters. The intertemporal elasticity of substitution of contemporaneous utility across consecutive years is represented by γ. Parameter θ indicates the extent to which households prefer immediate consumption and leisure to future consumption and leisure. This parameter is often called the extent of time preference. Next, parameter ρ is the elasticity of substitution between consumption and leisure within one period. Finally, parameter α represents the weight of leisure in the utility function.

2.2 Firms

The production block of the model can be described by a single representative firm. We assume that the firm produces a homogeneous output, which is demanded by households. In order to produce output and make a profit, the firm must make use of labour and capital. The firm chooses the amount of labour and investment and maximises the sum of present and expected profits, i.e. it maximises the discounted value of current and future dividends. The objective of the firm can be formally written as follows:

$$\max_{(K_1,\ldots,N_1\ldots)} \sum_{t=1}^{\infty} \prod_{i=2}^{t} \left(\frac{1}{1+r_i}\right) \pi_t \tag{2.8}$$

s.t.

$$\begin{aligned}
\pi_t &= Y_t - w_t N_t - I_t && t = 1, 2, \ldots && (2.9)\\
Y_t &= A\left(\epsilon K_t^{1-\frac{1}{\sigma}} + (1-\epsilon) N_t^{1-\frac{1}{\sigma}}\right)^{\frac{1}{1-\frac{1}{\sigma}}} && t = 1, 2, \ldots && (2.10)\\
K_{t+1} &= (1-\delta) K_t + I_t && t = 1, 2, \ldots && (2.11)\\
K_0 & \quad \text{given.} && && (2.12)
\end{aligned}$$

where Y_t represents aggregate production and N_t and K_t denote the aggregate amount of effective labour and the capital stock respectively. In each period capital depreciates at the rate δ. Parameter A characterises the overall productivity of the factors of production. We assume that there is exogenous labour-augmenting technological progress that increases the effective aggregate amount of labour. To be specific, following Miles (2002) we assume an age productivity profile ξ_t^s increasing over time at a constant growth rate. The aggregate amount of effective labour is defined by formula (2.15). Next, parameter ϵ denotes the weight of capital in the production process. The elasticity of substitution between labour and capital is captured by parameter σ.

2.3 Government

Incorporating the government into the model affects the model outcomes markedly. In particular, contribution rates and benefits directly change the price of labour and capital. Contrary to households and firms, we assume that the government does not optimise its behaviour. Thus, the government follows exogenously its set-up rule. In the simulation part, we analyse the impact of two alternative public budget closure rules. In particular, we assume that either the contribution rate or social security benefits adjust in order to balance public revenues and expenditures each year.

In what follows we simulate two alternative situations where the government either preserves the parameters of the current DB pension system or conducts a transition towards the DC

system, i.e. reduces the use of the DB system. In addition, we assume that the government can change the effective exit age of individuals from the labour market, i.e. it can affect the value of T^w. We show in the simulation part that in the case of some variables, retirement age postponement matters a lot. Still, our results show that even a significant extension of the average working age cannot prevent a deterioration in the generosity of the current social system. Total public revenues in period t are defined as:

$$R_t = \tau_t^y w_t N_t + \tau_t^y r_t A_t \tag{2.13}$$

where N_t, A_t and C_t represent aggregate employment, aggregate private wealth and aggregate private consumption respectively. In our analysis we restrict public expenditure only to benefits with respect to economically inactive people, i.e. elderly people:

$$E_t = \sum_s \text{dem}_t^s \cdot b_t^s \tag{2.14}$$

where b_t^s represents the amount of benefits going to elderly people at age s and year t. The vector dem_t^s corresponds to the size of each individual age group s in year t. Thus, the expression $\text{dem}_t^s \cdot b_t^s$ indicates the total amount of transfers going to age group s in period t. Finally, aggregation over all age groups gives the total amount of non-interest public expenditure in period t.

2.4 Equilibrium

In the equilibrium:

- the aggregate effective labour supply is the sum of the individual effective labour supply of economically active individuals:

$$N_t = \sum_{s=1}^{T^w} \text{dem}_t^s \cdot \xi_t^s \cdot n_t^s \tag{2.15}$$

- aggregate private wealth is the sum of individual private wealth over all individuals:

$$APW_t = \sum_{s=1}^{T^w+T^r} \text{dem}_t^s \cdot a_t^s \tag{2.16}$$

- labour supply equals labour demand, i.e. the wage clears the labour market;
- if the real interest rate is determined by the domestic supply and demand of capital then the level of domestic net foreign assets NFA_t is assumed to be fixed at the 2008 level and r_t clears the capital market;
- if the real interest rate is determined on the world capital market then the potential surplus or lack of capital is balanced by adjustment of NFA_t;
- the government follows the exogenous rule.

2.5 Model Calibration and Numerical Solution

Before providing simulation outcomes, the model needs to be calibrated in order to reflect the key characteristics of the economy. We calibrated the parameter values reflecting both relevant economic literature as well as the Czech reality. To be more specific, we adjusted the parameter values proposed by the literature so that the model replicates the actual 2006 data as closely as possible.

Households' reactions to changes in the economic environment are affected by the values of parameters γ, θ, ρ and α. The intertemporal elasticity of substitution γ refers to the extent to which households are willing to postpone current consumption spending in order to increase future consumption. The net rate of time preference, θ, sometimes called the subjective discount rate, indicates how individuals prefer current utility compared to future utility, i.e. to what extent individuals are patient. The elasticity of substitution between leisure and consumption is described by parameter ρ. Finally, parameter α shows the weight of leisure in the individuals' utility function. Firms' behaviour depends on parameters σ, ϵ and A. Parameter σ represents the elasticity of substitution between labour and capital. The capital intensity of production ϵ indicates the weight of capital in the production process. Parameter A represents total factor productivity.

As a starting point we apply parameter values based on the work by Auerbach and Kotlikoff (1989), Miles (2002), Rasmussen and Rutherford (2004), Catalán et al. (2007), Auerbach et al. (1989) and Martins et al. (2005) – see Table 2.1.

Table 2.1: Parameter Values

Parameter	Auerbach Kotlikoff	Miles	Russel	Martins et al.	Auerbach et al.	Dybczak 2008
γ	0.25	0.75	0.25	0.75	0.35	0.80
ρ	0.80	0.80	0.80	-	0.80	0.70
θ	0.02	0.02	0.01	0.03	0.02	0.01
α	1.50	0.33	0.40	-	1.50	1.54
σ	1.00	1.00	1.00	1.25	1.00	1.10

***Source**: Auerbach and Kotlikoff (1989)*, Rasmussen and Rutherford (2004), Martins et al. (2005), Auerbach et al. (1989).

Next, we adjust the parameter values so that the position of the Czech economy is reflected by the model outcomes. All data come from the national accounts reported by the Czech Statistical Office. In particular, the ratio of aggregate consumption to aggregate output is 0.48 and the ratio of total net wealth to aggregate output is about 4.1. The average real interest rate is set to 3%. Total resources are distributed between the firms' capital stock 93% and public debt 7%. The ratio of the first pension to the last wage is 70%.

Finally, taking into account the previous results of the above-mentioned authors and the Czech economic situation in 2006, we set parameters γ, ρ, θ, α as in Dybczak (2008), where details concerning the model calibration can be found.

Overall, the simulation outcomes can be affected by the assumed shape of the individual's labour productivity age profile ξ_t^s. Three alternative scenarios can be taken into account. First, ξ_t^s is independent of the age of individuals, i.e. the parameter is the same for all s . Second, ξ_t^s increases as individuals accumulate knowledge and experience. In this particular case, the shape of the productivity age profile is concave, i.e. individual productivity grows faster in the case of young individuals and then stabilises at a certain level. Third, ξ_t^s is concave as in the previous case, but this time it drops for older workers before reaching the retirement age. Unfortunately, neither the theoretical nor the empirical literature has provided a clear answer concerning the development of individuals' labour productivity over the life-cycle. Still, a substantial proportion of studies tend to support the third alternative, as documented by Kotlikoff and Wise (1989), Miles (1999) and Börsch-Supan and Essig (2003). Because of a lack of individual data in the case of the Czech Republic we assume $\xi_t^s = 1 + 0.0113s - 0.0003s^2$, following the work by Miles (1999) and Rasmussen and Rutherford (2004).[9]

Several numerical algorithms have been proposed in the literature in order to solve the above type of model numerically. The original work by Auerbach and Kotlikoff (1989) also provides an approach to solving the model. We apply the algorithm advocated by Auerbach and Kotlikoff.[10]

3. Implications of Demographic Changes for the Economy

In the following two subsections we present simulations of the potential implications of the expected demographic changes for overall economic development over the next 50 years. In this respect, special attention is paid to the effects of alternative government policies. In this study, we do not intend to provide an elaborate forecast of the near future. We instead focus on analysing the long-run impact of population ageing using a general equilibrium approach. We are aware that there are many other determinants which can significantly affect the course of the economy in the long run. Still, we believe that it is reasonable to investigate the isolated impact of the demographic transition, including alternative definitions of government revenue and expenditure rules, on the economy.

The model outcomes are presented as percentage deviations of the alternative scenarios from the baseline scenario. The baseline scenario assumes that there are no demographic changes as from 2008, i.e. that the population structure remains unchanged from 2008 onwards. On the contrary, the alternative scenarios reflect the expected demographic changes. The alternative scenarios are based on Eurostat's demographic projection EUROPOP (2008) as documented in Figure 1.1. The percentage deviation of the alternative scenario from the baseline scenario, which differ only with respect to the expected demographic changes, can be interpreted as the net impact of demographic factors on the course of a particular economic variable.

As will become evident in the following two sections, the role of demographic factors in

[9] The role of the three potential alternatives concerning the shape of the labour productivity age profile is discussed and assessed by Martins et al. (2005). In the case of the Czech Republic, Dybczak (2008) provides alternative simulations depending on the shape of the labour productivity profile, showing that the main conclusions of the analysis are not affected significantly when assuming an alternative shape of ξ_t^s. In addition, due to exogenous labour-augmenting technological progress, individual labour productivity ξ_t^s increases over time by 2% a year. Thus, the aggregate amount of effective labour is affected both by technological growth and by the age structure of the population.

[10] A detailed description of the numerical algorithm, including its application, is described for example by Heer and Maussner (2005).

the development of the economic variables turns out to be dominant. Still, alternative government policies can alter the overall impact of population ageing on the economy. To be more specific, we assume two alternative ways of balancing the public budget. First, public benefit expenditure b_t is fixed at the 2008 level while the contribution rate τ_t^y is adjusted in order to balance the revenue and expenditure sides of the budget. Second, the contribution rate τ_t^y remains constant at the current level while public benefit expenditure b_t is adjusted so that the budget is balanced each year. The two proposed government policy rules can be seen as the extreme cases of the future government policy set-up. Nevertheless, the assumption of a reduced relative value of public benefit expenditure is more realistic, since a number of European countries have already announced reforms aimed at limiting the generosity of their social security schemes.

In addition, we expand the set of simulation outcomes by introducing changes in the effective retirement age. In other words, we assume that the government either introduces reforms that stimulate individuals to postpone their exit from the labour market or sets rules that do not allow individuals to exit before achieving the statutory retirement age. Within each simulation, we assume that the retirement age remains unchanged at 60 years. Next, we assume that every 5 years the effective retirement age increases by 1 year until it reaches 63 years and then remains at this level. Finally, we assume that every 5 years the effective retirement age increases by 1 year until it reaches 65 years and then remains constant. Finally, we analyse the impact of the expected demographic changes subject to the alternative closure of the public budget and the value of the effective retirement age.

3.1 Determination of the Real Interest Rate on the Domestic Capital Market

Nowadays, in the era of developed capital markets and sophisticated financial instruments, the assumption that the real interest rate is determined domestically may be seen as somewhat restrictive. Nevertheless, some economic studies indicate that an important share of domestic investment is primarily financed from domestic saving. In particular, Feldstein and Horioka (1980) were among the first to point out a surprisingly high correlation between domestic saving and investment.[11] The results obtained led the authors to conclude that, given the existence of important barriers to investment abroad, the international mobility of capital is still rather restricted. Notwithstanding the significant progress achieved in the development of financial markets since the 1980s, including a decrease in barriers restricting investment abroad, empirical studies such as French and Poterba (1991) and Ahearne et al. (2004) find that individuals prefer investing an important share of their assets in the domestic financial market, despite the possibility of higher returns from investing abroad. It can be concluded that due to imperfect capital mobility national capital markets are partially isolated and the real interest rate is determined domestically to some extent. The following set of simulations assumes that the real interest rate is set domestically, i.e. that the real interest rate clears the domestic capital market.

All the alternative scenarios, which take into account future demographic changes, assume a significant increase in the share of elderly people, i.e. those individuals who do not work and enjoy public benefits. At the same time, the share of young working individuals falls. As a consequence of this exogenous assumption, the supply of labour diminishes as the number of economically active people decreases. The decline in the labour force simultaneously reduces government revenues and increases government expenditures. These two effects influence the government budget in the same direction, i.e. they tend to deepen the deficits in public financ-

[11] The seminal study by Feldstein and Horioka (1980) is cited as the basic reference on the issue of international capital mobility. Nevertheless, the conclusions of this study, as well as the way they were obtained, are often the subject of criticism – see e.g. Obstfeld and Rogoff (1996).

ing. Since the government is not allowed to accumulate public debt indefinitely, it must adapt the revenue and/or expenditure parameters of its budgets. In our study, we assume that the government balances the budget on a yearly basis.[12]

Generally, if the government decides to protect the current level of public benefit generosity, i.e. to preserve the parameters of the current DB pension system, it fixes the benefit-to-wage ratio at the 2008 level and increases successively the contribution rate as demand for public benefits increases in line with population ageing. Since changes in population composition and in the contribution rate influence the relative prices of labour, capital and leisure, both firms and households adjust their behaviour to the new conditions. First, a decrease in the ratio of economically active individuals to the total population leads to a fall in aggregate labour supply, which in turn implies an increase in the price of labour. On the other hand, an increase in the contribution rate augments the cost of labour for firms and reduces the disposable income of households. The burden of the increased contribution rate is therefore split between firms and households, which demand and supply labour respectively. Next, households' income during retirement is guaranteed by the government. All these factors have important implications for the future development of the economic variables.

On the aggregate level, as shown in the right-hand part of Figure 3.1, total employment N(τ) significantly falls within a range of 10 to 20 per cent. The lack of labour translates into a higher wage rate w(τ) – see Figure 3.1. In addition, as the relative value of public benefits is guaranteed, individuals are not motivated to accumulate additional savings and hence total private wealth falls. Consequently, the aggregate capital stock K(τ) shrinks to an equal extent as aggregate private wealth – see the right-hand part of Figure 3.1. Still, due to the enormous reduction in total employment, a part of the capital stock becomes obsolete, i.e. total employment drops by more than the total capital stock. As the real interest rate is a function of the capital stock per unit of effective labour, the real interest rate ir(τ) falls over the next 50 years by about 10 per cent as shown in the right-hand part of Figure 3.4. Indeed, as aggregate employment and the capital stock diminish, aggregate production Y(τ) adjusts in the same direction – see Figure 3.5, on the right. Because government revenues follow the path of overall economic activity pretty closely, the government has to adjust the contribution rate in order to finance the increasing level of expenditure. The development of the stabilising contribution rate τ_t shown in the right-hand part of Figure 3.6 demonstrates that in 50 years the contribution rate would have to be more than 40 per cent higher compared to the baseline scenario of no demographic changes.

Alternatively, should the government decide to keep the existing contribution rate, public expenditures must be reduced. Faced with the problem of rising expected expenditures and falling expected incomes, the government thus reacts in a different way compared to the previous case. Now, by lowering expenditures associated with economically inactive individuals, the government gives a sufficient stimulus to both older and younger individuals to adjust their behaviour to the new conditions. In particular, younger individuals are aware of the need to better secure their sources of income in order to cover their consumption expenditure during retirement. From an institutional point of view, the government reduces the role of the DB pension system and supports a transition towards the DC system.

[12] The strict balanced budget rule seems to be an unrealistic assumption. Nonetheless, this rule is still found to be reasonable for the analysis of the long-run effects of alternative policies under population ageing. See for example Bösch-Supan et al. (2004) or Miles (1999).

On the aggregate level, similarly to the previous scenario, we explicitly assume a decrease in the labour force. The decline in aggregate employment $\mathrm{N}(b)$ is, however, not as pronounced as in the case of a rising contribution rate, because individuals now supply more labour in an effort to earn additional income – see Figure 3.1. In addition, three factors – a reduced value of public benefits, a fixed contribution rate and a higher wage – stimulate individuals to work more. The development of the wage rate $\mathrm{w}(b)$ and public benefits b is depicted in the left-hand part of Figure 3.1 and Figure 3.6 respectively. Consequently, working individuals accumulate more private wealth $\mathrm{APW}(b)$ compared to the baseline case. Since the overall development of the aggregate capital stock $\mathrm{K}(b)$ is almost stabilised over the projection period and the reduction in total employment $\mathrm{N}(b)$ is somewhat dampened, aggregate production $\mathrm{Y}(b)$ does not fall as extensively as in the previous scenario – see Figures 3.1, 3.1 and 3.5. Similarly to the previous scenario, the ratio of capital to effective employment increases, but this time the increase is more pronounced and the real interest rate $\mathrm{ir}(b)$ drops more markedly, as shown in Figure 3.4.

Comparing the two types of simulations, one can conclude that the development of some variables, for example aggregate private wealth, can be substantially different. On the contrary, the economic implications of the expected demographic transition under the alternative government policies are relatively comparable. Notably, in both scenarios the ratio of capital to a unit of effective labour increases and the real interest rate drops. Concerning the expected development of the real interest rate, the role of demographic factors turns out to be predominant. Even though the implications of the balancing contribution rate and public benefits for some economic variables are diverse, their impact on the ratio of capital to a unit of effective labour is identical. Generally it holds that the expected demographic changes would lead to an increase in the capital share per unit of effective labour, and thus to a decrease in the real interest rate. The magnitude of this change depends on the way the public budget balance is achieved. Intuitively, the real interest rate drops more if individuals are motivated to accumulate a higher level of wealth.

An increase in the retirement age can significantly affect the course of the economy. In particular, the development of some variables is very sensitive to that assumption. Still, even the relatively high increase in the retirement age which we take into consideration cannot outweigh the dominant effect of the envisaged demographic changes. Overall, one can conclude that regardless of the public budget closure rule and the retirement age, overall economic activity will be affected significantly by population ageing. In particular, it turns out that aggregate employment, aggregate output and the real rate of return on assets, among others, will be affected most.

Figure 3.1: Employment

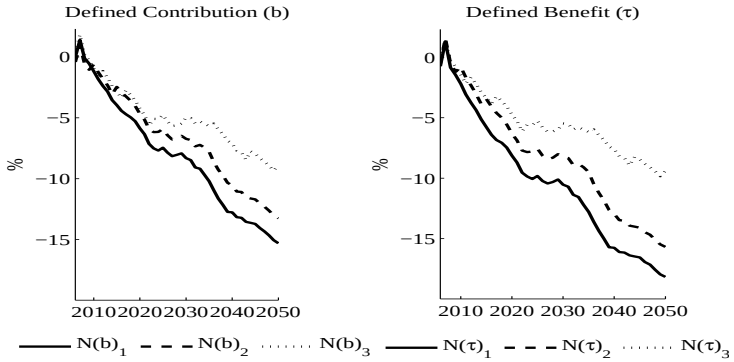


Figure 3.2: Wage

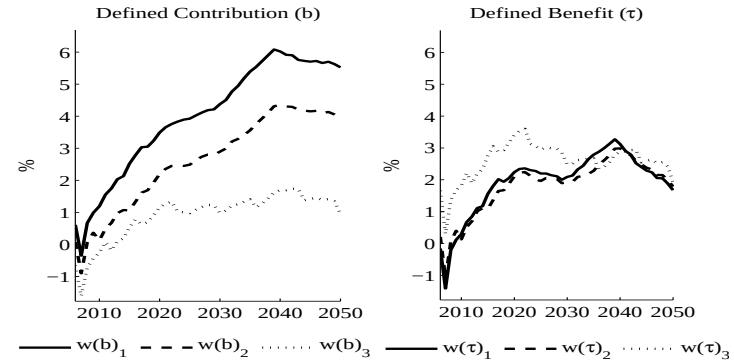
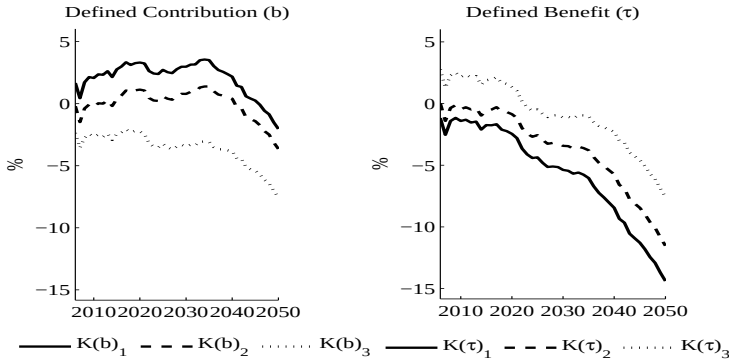


Figure 3.3: Capital Stock



Note: Defined contribution (b) means that the income tax rate τ is fixed and the value of pension benefits b adjusts. Defined benefit (τ) indicates that the relative value of public benefits is fixed and income tax τ adjusts.
The lower-case indices 1, 2 and 3 denote the following three scenarios:
1: the statutory retirement age is 60 years;
2: the statutory retirement age increases by one year every five years until reaching 63 years;
3: the statutory retirement age increases along with increasing life expectancy.
Source: Authors' calculations.

Figure 3.4: Interest Rate

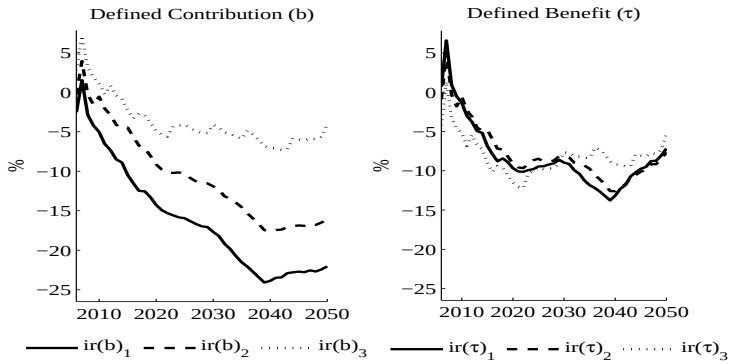


Figure 3.5: Production

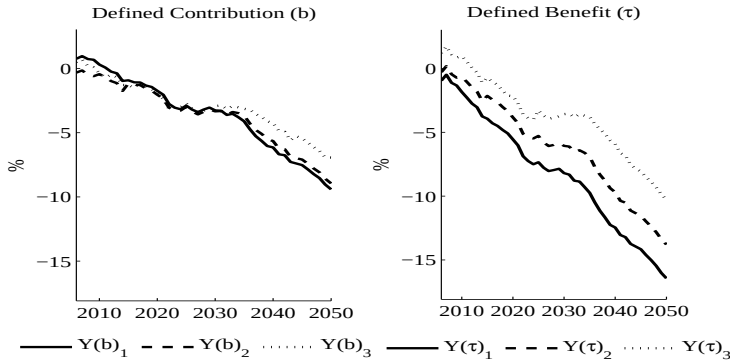
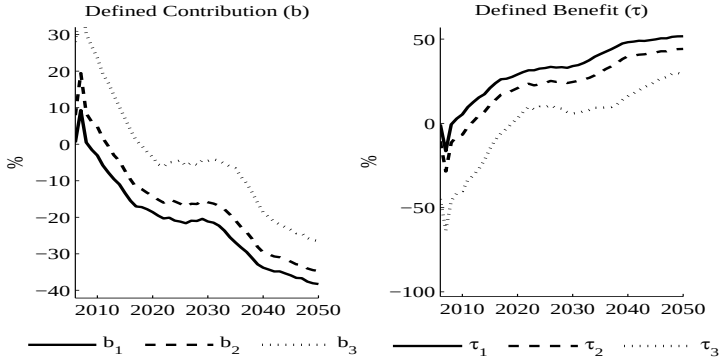


Figure 3.6: Social Security Benefit and Contribution Rate



Note: Defined contribution (b) means that the income tax rate τ is fixed and the value of pension benefits b adjusts. Defined benefit (τ) indicates that the relative value of public benefits is fixed and income tax τ adjusts.
The lower-case indices 1, 2 and 3 denote the following three scenarios:
1: the statutory retirement age is 60 years;
2: the statutory retirement age increases by one year every five years until reaching 63 years;
3: the statutory retirement age increases along with increasing life expectancy.
Source: Authors' calculations.

3.2 Determination of Capital Flows between the Domestic Economy and the Rest of the World

The dynamics of international capital flows are determined by many factors, including demographic ones. Empirical studies confirm the existence of a relationship between the demographic structure, the amount of saving and investment, and capital flows. The relationship between capital flows and demographic structures can be built upon two assumptions. On the one hand, countries with a higher share of younger inhabitants have a stronger aggregate labour supply, which must be complemented by a corresponding amount of capital in order to produce output. Since younger individuals are characterised by a low level of individual wealth, the economy must borrow the required stock of capital abroad. On the other hand, countries with a higher share of older inhabitants are characterised by lower aggregate employment and a higher level of individual wealth. By trying to achieve higher capital returns and diversify their portfolios, individuals may decide to invest a part of their wealth abroad. Thus, the economy as a whole can export a part of its capital abroad. In other words, the demographic changes imply a reallocation of capital from countries with older populations to countries with younger populations.

Notice that the direction and magnitude of capital movements between the domestic and foreign economies depend on a number of factors. The key role is played by the preferences of individuals, who, by trying to smooth their consumption over time, decide whether to borrow from abroad or to invest abroad. Investment abroad becomes attractive if domestic investment opportunities are viewed as being limited. Hence, the balance of payments can be viewed as the outcome of the intertemporal decision-making of individuals in the open economy. The validity of this relationship is empirically verified for a group of countries by Higgins (1998). The author also shows that the share of economically active individuals goes hand in hand with the development of the balance of payments. Using the overlapping generation model Domeij and Flodén (2004) and Bösch-Supan et al. (2004) simulate the potential role of demographic factors in international capital flows.

Since our model focuses on the effects of demographic factors, which change quite slowly, it is obvious that the model will not be able to capture short-term changes in the balance of payments. Still, Domeij and Flodén (2004) subject this model to empirical verification with the objective of simulating the development of the current account of the balance of payments in the OECD countries for the period from 1960 to 2003. The model's predictions are then assessed against the actual data. Despite the model's simplifying assumptions, the authors find that the model is able to explain a small but statistically significant share of capital flows.

In the current set of simulations, the trajectory of the world real interest rate is exogenous. The expected development of the real interest rate over the next 50 years is taken from Miles (1999), who considers the European Union as a closed economy and assumes that the real interest rate is an outcome of the interaction between capital supply and demand in the EU. Comparable results are provided by McMorrow and Röger (2003), who apply a multi-country OLG model. In both cases, the real interest rate is assumed to decrease by 13 per cent over the next 50 years. As presented in the previous subsection, the real interest rate is expected to drop much more (up to 30 per cent depending on the type of fiscal adjustment) where we assume that the real interest rate is determined on the domestic capital market. The world real interest rate does not drop so much, since the development of capital demand and supply among national economies is not identical and the worsening of the demographic structure in the rest of the world is not as pronounced as in the Czech Republic.

Although the rate of return on capital represents an important aspect of the investment-saving decisions of individuals, other factors – such as the system of taxes or public expenditures – matter as well, in addition to the demographic changes. In line with the previous subsection we provide a set of simulations reflecting both alternative government policies and increasing retirement age.

Should contribution rates increase, given a guaranteed value of future income, individuals will be motivated to work less and to accumulate less savings. Still, at the same time the increasing contribution rate will reduce demand for domestic labour. Overall, individuals will accumulate higher wealth than the amount demanded by domestic firms and a part of capital will also be invested abroad.

On the aggregate level, firms choose the amount of capital stock which maximises their profit. At the same time, firms' demand for capital is affected by the disposable amount of labour. In line with the previous scenarios, we assume that the aggregate labour force N(τ) shrinks due to the demographic transition, which affects the development of aggregate employment, as documented in the right-hand part of Figure 3.7. In addition, the drop in labour demand is more pronounced due to the higher contribution rate τ_t – see Figure 3.11. Surprisingly, however, individuals are not motivated too much to accumulate additional private wealth APW(τ) – see Figure 3.8. A part of aggregate private wealth becomes obsolete in the domestic economy. Consequently, the aggregate capital stock K(τ) adjusts downwards as shown in the right-hand part of Figure 3.9. Indeed, the drop in aggregate employment and the capital stock leads to a fall in aggregate output Y(τ) – see the right-hand part of Figure 3.10. The main assumption of the current scenario is that firms decide how much capital to use and households decide how much to save. Where the quantity of capital demanded and supplied is not the same, the residual of the two is either exported to or imported from abroad. As already described, a part of domestic private wealth becomes obsolete and is exported abroad. In consequence, the value of net foreign assets grows over time, as domestic investment opportunities are limited. The development of net foreign assets NFA(τ) is depicted in the right-hand part of Figure 3.12. As the value of net foreign assets initially increases and then stabilises, the current account CA(τ) initially tends to be positive and then approaches zero.

On the contrary, if the government decides to revise the value of social benefits, households will accumulate a higher value of wealth in order to cover future consumption expenditure. Intuitively, as capital demand remains almost unchanged between the two scenarios, the amount of private wealth which becomes obsolete is higher and the increase in the value of net foreign assets is more pronounced. Consequently, the current account balance is positive.

In the case of a decrease in social expenditures, individuals will be motivated to save more in order to cover their expected consumption expenditure during retirement. The expected development of aggregate private wealth APW(b) under the current assumptions is depicted in the left-hand part of Figure 3.8. Even though aggregate employment N(b) does not fall as much as in the previous scenario (see Figure 3.7), firms will not demand as much capital as accumulated by domestic households. The left-hand part of Figure 3.9 shows that the capital stock K(b) develops roughly in line with aggregate employment. Because both the aggregate capital stock and employment drop, aggregate production Y(b) shrinks as well – see Figure 3.10. Consequently, similarly to the previous scenario, the difference between the value of aggregate private wealth and the capital stock translates into the accumulation of net foreign assets NFA(b) – see the left-hand part of Figure 3.12. Clearly, thanks to the reduction in the

generosity of public benefits, such a scenario is associated with an even stronger increase in aggregate private wealth and net foreign assets. Hence, one can conclude that due to the expected demographic changes and the declining generosity of the social system, a significant increase in aggregate private wealth can be expected. Moreover, a large amount of this wealth will be reallocated abroad, which will have a positive impact on the current account of the balance of payments CA(b).

Figure 3.7: Employment

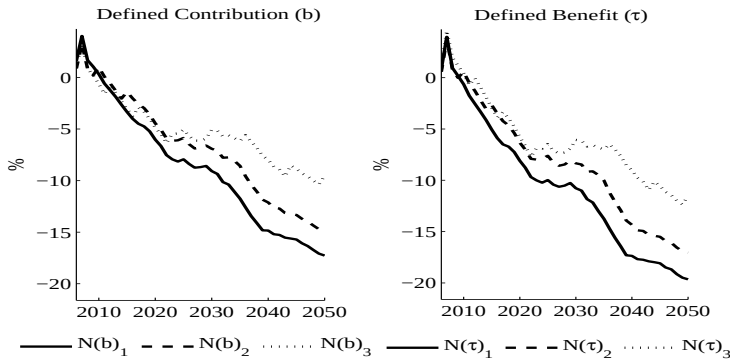


Figure 3.8: Aggregate Private Wealth

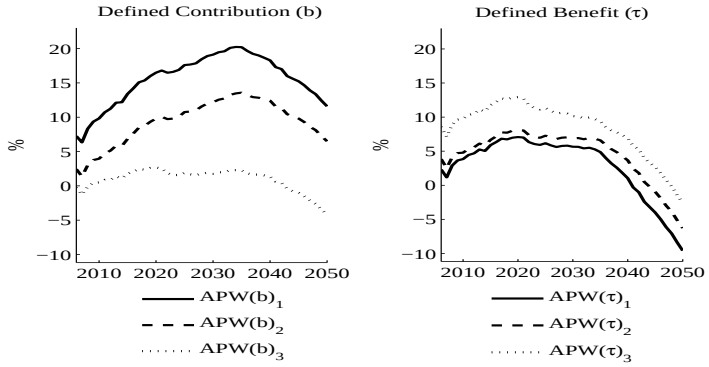
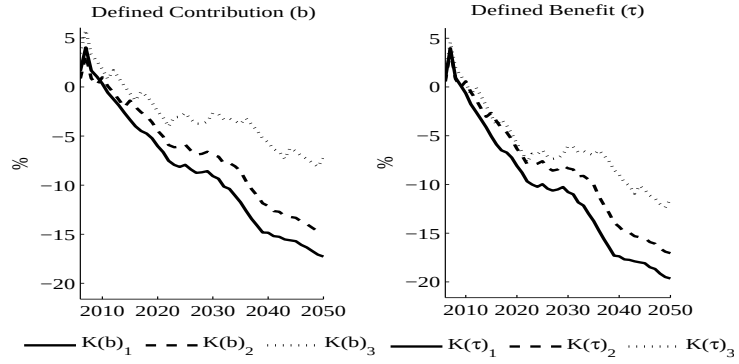


Figure 3.9: Capital Stock



Note: Defined contribution (b) means that the income tax rate τ is fixed and the value of pension benefits b adjusts. Defined benefit (τ) indicates that the relative value of public benefits is fixed and income tax τ adjusts.
The lower-case indices 1, 2 and 3 denote the following three scenarios:
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2: the statutory retirement age increases by one year every five years until reaching 63 years;
3: the statutory retirement age increases along with increasing life expectancy.
Source: Authors' calculations.

Figure 3.10: Production

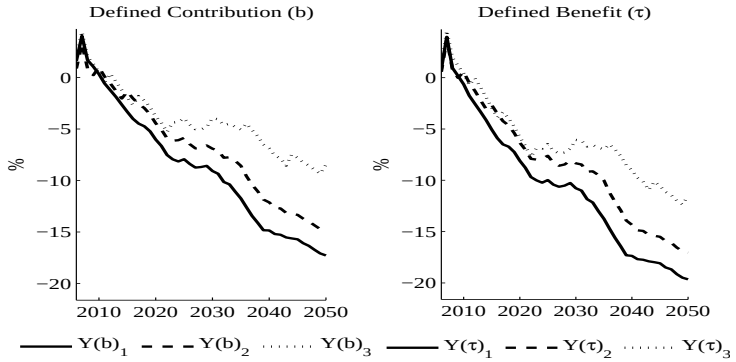


Figure 3.11: Social Security Benefit and Contribution Rate

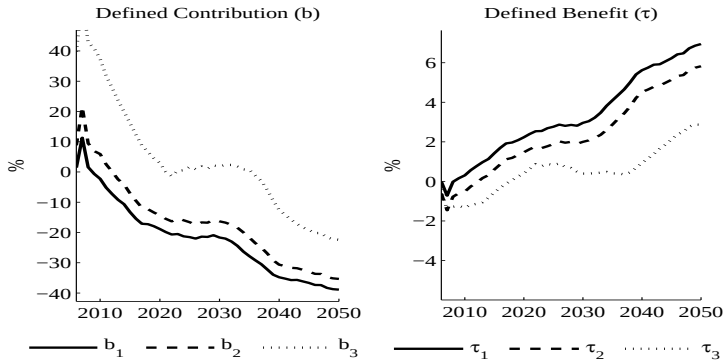
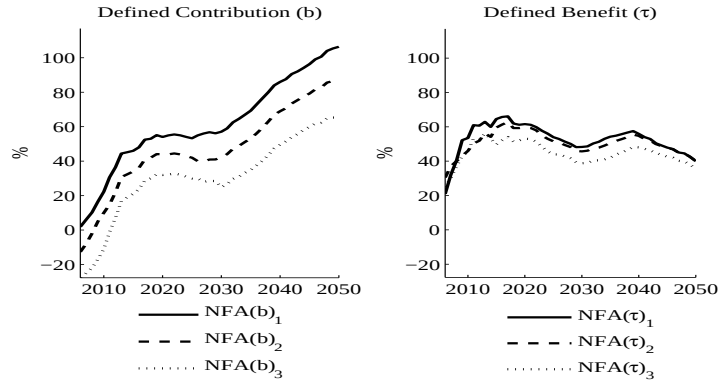


Figure 3.12: Net Foreign Assets



Note: Defined contribution (b) means that the income tax rate τ is fixed and the value of pension benefits b adjusts. Defined benefit (τ) indicates that the relative value of public benefits is fixed and income tax τ adjusts.
The lower-case indices 1, 2 and 3 denote the following three scenarios:
1: the statutory retirement age is 60 years;
2: the statutory retirement age increases by one year every five years until reaching 63 years;
3: the statutory retirement age increases along with increasing life expectancy.
Source: Authors' calculations.

4. Conclusion

In the coming 50 years the Czech Republic is very likely to face substantial demographic changes. Evidently, these changes might have a significant impact on the functioning of the Czech economy. Using a computable overlapping generation model we assess the impact of the expected demographic changes on the development of the Czech economy taking into account alternative government budget policies and postponement of the retirement age.

Based on the demographic projection EUROPOP (2008) provided by Eurostat, our simulations show that aggregate employment is expected to fall by 10 to 20 per cent compared to the baseline scenario, under which the size and structure of the Czech population remain at the 2008 levels. As labour becomes scarce in the economy, capital demand drops in line with the development of aggregate labour supply. As a consequence, either the domestic real interest rate adjusts downwards or a part of the domestic capital stock is exported abroad. Concerning the development of the domestic real interest rate, it is expected to drop with respect to the baseline scenario by 10 to 20 per cent during the next fifty years. We expect the value of net foreign assets to increase within the range of 50 to 100 per cent due to demographic factors. Generally, one can expect that over the next five decades the return on domestic assets will fall substantially or a part of domestic wealth will be transferred abroad.

We conclude that the main driving forces behind the key results of this study are primarily affected by the expected deterioration of the demographic structure. Alternative assumptions concerning the type of pension system and the retirement age threshold affect the outcomes of the analysis as well; however, the overall impact of demographic changes is not eliminated. Nevertheless, the model outcomes illustrate that the impact of population ageing seems to be higher when the current DB pension scheme is assumed. Under this assumption, the generosity of the pension system is preserved and individuals are not motivated to work and save more when young. On the contrary, the impact of ageing is lower when one assumes a DC pension scheme, where the generosity of the public pension scheme is reduced and subsequently individuals are motivated to supply more labour and save for the later stage of life.

The results are in line with the current developments in many European countries where the role of DC schemes has been fostered and the significance of DB schemes has been suppressed. For example, a number of countries (Bulgaria, Estonia, Latvia, Lithuania, Hungary, Poland, Slovakia and Sweden) have implemented systemic pension reforms shifting part of the previously public pillar to a mandatory funded private pillar. In addition, a few European countries (Germany, Slovenia, Finland, Italy, Portugal and Sweden) have modified their pension systems by introducing mechanisms that change the size of the pension benefit depending on expected demographic changes such as life expectancy at the time of retirement.[13]

[13] An extensive description of pension scheme reforms and their expected impacts on European countries is provided by EPC-AWG (2009).

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