OECD Economics Department Working Papers No. 1657

A simulation framework to project pension spending: The Czech pension system

Falilou Fall,

Paul Cahu

https://dx.doi.org/10.1787/e4e79fad-en

OECD

Organisation for Economic Co-operation and Development

ECO/WKP(2021)8

Unclassified

English - Or. English

9 February 2021

ECONOMICS DEPARTMENT

A SIMULATION FRAMEWORK TO PROJECT PENSION SPENDING: THE CZECH PENSION SYSTEM

ECONOMICS DEPARTMENT WORKING PAPERS No. 1657

By Falilou Fall and Paul Cahu

JT03471091

ABSTRACT/RÉSUMÉ

A simulation framework to project pension spending: the Czech pension system

This paper presents a simulation framework developed to assess the impact of ageing on the financial sustainability of the Czech pension system. It accompanies the publication OECD *Reviews of Pension Systems: Czech Republic*. The framework has two components: a macroeconomic model to project long-term GDP and a cohort model to simulate the evolution of pensions. The macroeconomic model takes into account the evolution of the labour force and productivity. The cohort model simulates the career of a representative sample of the working-age population and their path in retirement. It replicates and projects the main features of the labour market, in particular, participation, wage and unemployment. It captures non-linear features of the pension system and distributional effects. The model estimates and simulates the main demographic variables of the pension system, in particular, the number of old-age pensioners and disability pensioners. It allows to simulate different policy options to close the financing gap of the pension system.

Pension spending is projected to increase to 11.9% of GDP in 2060 from 8.2% in 2018, leading to increasing deficits of the pension system. Among the different options to close the financing gap, further increasing the retirement age after 2030 in line with life expectancy gains appears to be the most efficient policy measure to boost growth and reduce the financing needs. However, additional measures would be needed to close the financing gap of the pension system.

Keywords: Ageing; pensions; pension reform; financial sustainability of pension systems; Czech Republic; pension simulation framework; Pay-as-you-go system.

JEL Classification: H55; J11; J26 ; J18

*****

Un cadre de simulation pour projeter les dépenses de retraite : le système de retraite tchèque

Cet article présente le cadre de simulation développé pour évaluer l'impact du vieillissement sur la viabilité financière du système de retraite tchèque. Il accompagne l'Examen des pensions de l'OCDE de la République tchèque. Le cadre comporte deux composantes : un modèle macroéconomique pour projeter le PIB à long terme et un modèle de cohorte pour simuler l'évolution des retraites. Le modèle macroéconomique prend en compte l'évolution de la population active et de la productivité. Le modèle de cohorte simule la trajectoire de carrière d'un échantillon représentatif de la population en âge de travailler et son parcours à la retraite. Il reproduit et projette les principales caractéristiques du marché du travail, en particulier les taux d'activité, le niveau et la répartition des salaires et les épisodes de chômage. Il saisit les caractéristiques non linéaires du système de retraite et les effets distributifs. Le modèle estime et simule les principales variables démographiques du système de retraite, en particulier le nombre de retraités et de pensionnés d'invalidité. Il permet de simuler différentes options de réformes pour combler le déficit de financement du système de retraite.

Les dépenses de retraite devraient augmenter à 11,9% du PIB en 2060 contre 8,2% en 2018, ce qui entraînera une augmentation des déficits du système de retraite. Parmi les différentes options pour combler le déficit de financement, une nouvelle augmentation de l'âge de la retraite après 2030 en fonction des gains d'espérance de vie semble être la mesure la plus efficace pour stimuler la croissance et réduire le financement nécessaire. Cependant, des mesures supplémentaires seraient nécessaires pour combler le déficit de financement du système de retraite

Mots-clés : Retraite ; soutenabilité financière des systèmes de retraite ; réforme retraite; simulation des systèmes de retraite ; système par répartition, vieillissement ; République Tchèque

Classification JEL : H55; J11; J26 ; J18

Table of contents

Tables

Figures

Boxes

A simulation framework to project pension spending: the Czech pension system

Falilou Fall and Paul Cahu[1]

1. Introduction

1. This paper presents the simulation framework developed to assess the impact of ageing on the financial sustainability of the Czech pension system. The framework is also used to simulate different options for policy reforms. It accompanies the OECD *Reviews of Pension Systems: Czech Republic*.

2. The framework has two components: a macroeconomic model to project long-term GDP and a cohort model to simulate the evolution of pension spending. The macroeconomic model takes into account the evolution of the labour force and productivity to project GDP growth.

3. The cohort model simulates the career path of a representative sample of the working-age population and their path in retirement. It replicates and projects the main features of the labour market, in particular, participation rates, the level and distribution of wages and unemployment spells. It captures non-linear features of the pension system and distributional effects. The model estimates and simulates the main demographic variables of the pension system, in particular, the number of old-age, survivor and disability pensioners. Then, the current rules of the pension schemes are applied to project revenues and spending of the pension system.

4. Pension spending is projected to increase to 11.9% of GDP in 2060 from 8.2% in 2018, leading to increasing deficits of the pension system. To cope with this financial strain, reducing pension levels does not seem adequate as Czech pension levels are relatively low compared to many OECD countries. Among the different options to close the financing gap, further increasing the retirement age after 2030 in line with life expectancy gains appears to be the most efficient measure to boost growth and reduce the financing needed.

5. However, additional measures would be needed to close the financing gap of the pension system. For instance, increasing government budget transfers could finance the redistributive component of the pension system. To finance the additional resources needed the simulations indicate that increasing profits and corporate income taxes would have less negative impacts on GDP and employment than increasing social contributions and value added tax. Increasing social contributions should be avoided, as they are

[1] Falilou Fall is a Senior Economist in the OECD Economics Department and Paul Cahu is an OECD Consultant. This paper was a technical background paper of the OECD Reviews of Pension Systems: Czech Republic. The authors are grateful for the comments and discussions with experts from the Czech Ministry of Finance Jindrich Marval and Stork Zbynek and from the Czech Ministry of Labour and Social Affairs Marek Suchomel and Jan Skorpik. We are also grateful for comments from OECD colleagues Pablo Antolin and Stéphanie Payet (DAF directorate) and Monika Queisser, Hervé Boulhol and Christian Geppert (ELS directorate) and Mame Fatou Diagne and Yvan Guillemette (ECO directorate). We are grateful to Ota Melcher and Eva Nemeckova for highly appreciated help and constructive suggestions. We thank Poeli Bojorquez for publication assistance.

already high and could start to have detrimental effects on employment. Indeed, the Czech Republic's tax wedge is among the highest across the OECD and the average rate of employers' social contributions is the second highest.

6. The structure of the paper is as follows: in section 2. , an overview of the Czech pension system and of the simulation framework is presented. In section 3. , demographic evolutions are analysed. Section 4. presents the macroeconomic framework and the long-run projection of GDP. Section 5. presents the different steps of the cohort model. Labour market projections are developed, careers and wage distribution modelled and contribution periods validated. Section 6. describes and estimates the number pensioners and spending in the different schemes. Section 7. discusses financial projections for the pension system. Finally, section 8. presents the quantification of options for policy reform.

2. Overview of the public pension system and the simulation framework

2.1. The Czech pension system

7. The Czech pension system has two pillars: the main pillar is a mandatory state Pay-As-You-Go (PAYG) system and the supplementary pillar is a voluntary private fully funded system. There is no occupational pension scheme. The mandatory basic pension scheme covers all economically active individuals. The Czech Social Security Administration manages the mandatory basic pension scheme. Armed forces (e.g. soldiers, policemen, fire fighters) have their pension insurance administered by their respective ministries in charge but eligibility conditions are the same as in the "main" scheme.

8. The state PAYG pension system covers three main benefits – old-age pensions, disability pensions and survivors' pensions. The two main eligibility conditions to qualify for an old-age pension are the insurance period and the statutory retirement age. The insurance period includes contributory periods and covered non-contributory periods such as maternity leaves, insured unemployment periods and some non-insured unemployment periods, and education periods for some generations. In addition to reaching the statutory retirement age, the required insurance period for a pension is at least 35 years or 30 years of contributed period; or at least 15 to 20 years of insurance period and be 5 years older than the statutory retirement age. In 2020, the statutory retirement age is 63.5 years for men and 63 years and 2 months for women without children. The statutory retirement age is increasing gradually to 65 years in 2030 for both men and women (until 2037 for women with children). There are possibilities of early retirement under tight conditions (OECD, 2020).

9. The old-age pension consists of an earnings-related component and a basic, flat-rate component. Persons eligible for the earnings-related component receive the basic pension, which is equal to 10% of the average wage. It is the same for all pensioners regardless of insured periods or individual earnings.

10. The earnings-related component of the old-age pension depends on the insurance period and career earnings. The earnings-related pension gives 1.5% of the reference wage for each full year of insured period. To calculate the reference wage and therefore pension benefits, a progressive formula is used under which income thresholds are applied. Up to the threshold of CZK 14 388 in 2019 (44% of the average wage), wages are fully taken into account. Between this threshold and the pensionable earnings cap (CZK 130 796, 400% of the average wage), only 26% of earnings are taken into account. Earnings over the cap are not taken into account. The average of all earned wages since 1986 is taken into account to calculate the reference wage by uprating past wages with the economy-wide average wage growth. Non-validated periods are included in the reference wage as zeros (OECD, 2020).

11. Pension contributions finance old-age (both earnings-related and basic), survivor and disability pensions. Pension contribution rates are 28% of wages, split between employers (21.5%) and employees (6.5%). More precisely, the contribution rate is applied to all the benefits paid by the employer to the

employee, which are also subject to personal income tax. Contributions are paid on earnings up to four times the average wage. Earnings above the contribution threshold have been subject to a higher income tax rate since 2013 such that the total of the tax rate and contribution rate remains constant above the contribution threshold.

12. Self-employed persons have their own income assessment base amounting to 50% of the difference between incomes and expenses (profits). The minimum base for contribution is, however, 25% of the average gross monthly wage in the economy and the maximum base is four times the average wage (the same as for employees). The contributory rate for self-employed persons is 28%.

13. Disability pensions are the second component of the state PAYG pension scheme. Individuals losing 35% or more of their ability to work can receive a disability pension if they have at least 5 years of insurance period. There are three degrees of disability with a pension rate associated to each degree of disability. The first degree of disability corresponds to a decline in working capacity of at least 35% but not more than 49%; the second degree of disability, a decline of at least 50% but not more than 69%; and the third degree of disability to a decline of at least 70% (full disability). The earnings-related component of the disability pension is calculated as the degree's pension rate times the reference wage for each full year of insured period. However, periods in disabled status before statutory retirement age are counted as insured periods. At statutory retirement age, the disability pension is transferred to the old-age pension scheme.

14. Survivor pensions are the last component of the state PAYG pension scheme. Survivor pensions are paid out to a widow/widower or an orphan (dependent child) if a deceased person has met eligibility conditions for the old-age or disability pension or has died due to a job-relating injury. After one year of receiving the survivor's pension, the widow/widower must meet additional conditions to keep the survivor pension, among which caring for a dependent or disabled child, parents or relatives aged 80 and higher or being disabled in the third degree of disability or retired (see Czech Ministry of Finance, 2017). The earnings-related component of the survivor pension amounts to 50% of the earnings-related component of a spouse's old age or disability pension of the third degree. For orphans' pensions, a 40% rate is applied instead of 50%.

15. Workers and self-employed individuals have access to an optional supplementary pension system. It is a voluntary, fully-funded and state-subsidised defined contribution (DC) pension scheme. It also includes life insurance as a product of commercial insurance companies. Employers can complement employees' contributions with additional contributions to employees' funds. Both, employer and employee contributions are subject to additional tax allowances (OECD, 2020).

2.2. Overview of the simulation framework

16. The simulation framework is based on the Czech Statistical Office demographic projections. It has two components, a macroeconomic model to project the evolution of GDP up to 2070 and a cohort model to project the different schemes of the pension system. Only the components of the state PAYG mandatory scheme are projected. The voluntary fully-funded private system is not projected.

17. A long-term general equilibrium model is developed, including the evolution of the labour force, to project GDP growth. The model takes into account the impacts of long-term factors on unemployment and GDP, especially demography, productivity and structural factors.

18. The cohort model simulates the career path of a representative sample of the working-age population and their path into retirement. It is calibrated to match the main features of the labour market and of the pension system. In particular, career salaries are simulated. The cohort model allows precise simulations of the rules of the pension system, to incorporate the non-linearity in the rules and to produce the distributional impacts of reforms (see Fall, 2014).

19. More precisely, the model simulates for each cohort (that is born a specific year) 2000 nationals and 94 immigrants, split equally between women and men. Each year, cohorts are aged from 19 to 64 years (94 230 individuals in total). Each individual is weighted in the model to reflect the mortality profile. These individuals live from age 19 to 99 in the model, subject to expected mortality. The model simulates the pension system from 1986 to 2070. Individuals are assigned an education level according to the distribution of education levels in their cohort, and women are assigned the number of children consistent with observed and forecasted fertility rates.

20. The model simulates the career of individuals from age 19 to 69, with one observation per year, for labour market participation, unemployment, disability status, self-employment status and wages. Wages are drawn randomly, with their level depending on age, gender, disability status and education.

21. The different sources of validation of contribution periods include contributed periods for employees and the self-employed, insured unemployment periods, education periods before 2009 and maternity and parental leaves for women.

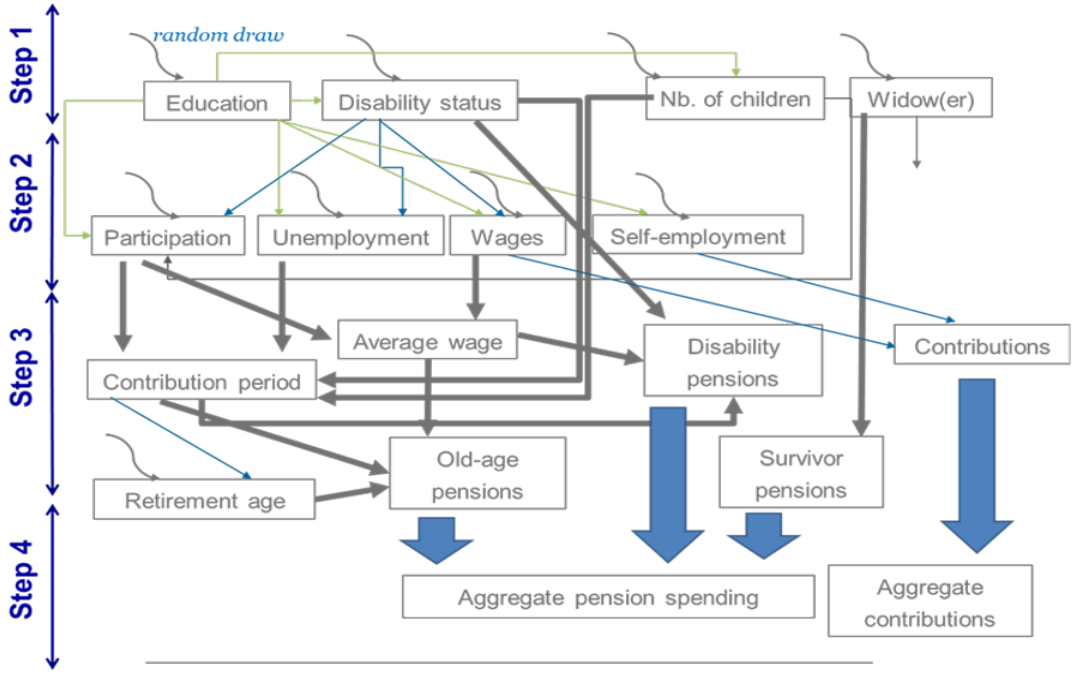
22. Survivor and disability schemes are simulated based on estimated probabilities of being disabled or a widower/widow.

23. The retirement decision is based on the duration of contributions, which reflects careers. Individuals are assumed to retire as soon as the mandatory contribution period and the retirement age are reached, as only a tiny fraction of each cohort actually choses to work longer. The pension level is determined according to current rules.

24. Figure 1 illustrates the structure of the cohort model and the different steps of the simulation. There are four main steps. The first step draws the main characteristics of individuals entering the labour force, including their level of education. The second step simulates the career path by determining for every year: participation in the labour market, type of activity (employee or self-employed), employment status and wages. The third step determines the number of contribution periods validated. The last step applies the retirement decision rule and establishes the pension status and level.

25. As for any projection and simulation, there are assumptions and methodological choices that may affect the results at the margin. Overall, the projections are robust but may deviate from other projections due to differences in methodology and assumptions. For instance, our random drawing strategy creates some variance in the distribution of variables like wages, participation and unemployment thus affecting the number of contribution periods validated. Also, we use a yearly modelling strategy which may minimise infra-year retirement decision. Moreover, due to lack of information, some elements like periods validated for family care and military careers are not included, however, that is comparable to EU projections. Moreover, the COVID-19 crisis may have long-run effects on potential output which are not taken into account.

Figure 1. The cohort model's structure



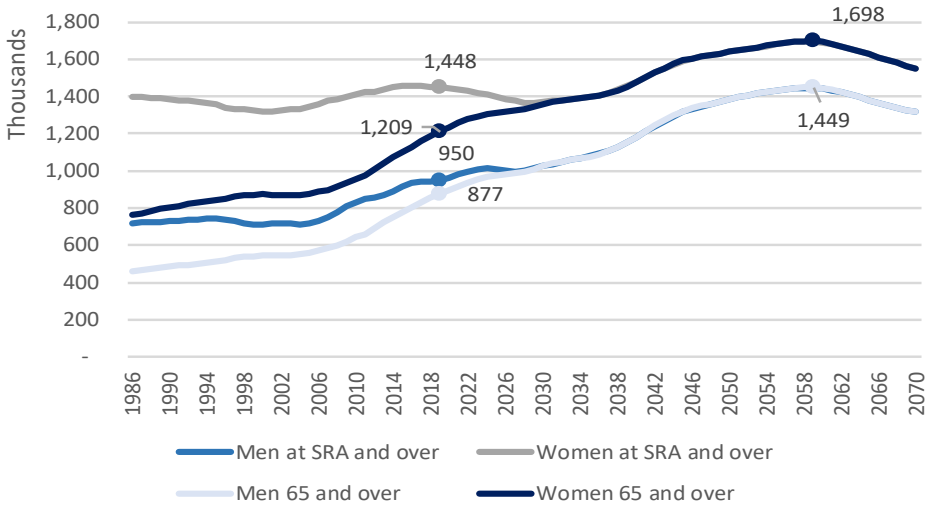
3. Demographic projections

3.1. Projections of the elderly population

26. Demographic projections are from the Czech Statistical Office. The elderly population in the Czech Republic, people aged 65 and over, is projected to increase by about 50% from 2019 to 2060, the peak year (Figure 2). This increase will be higher for men – about 65% – than for women – about 40% – because male life expectancy is supposed to converge progressively toward that of women.

27. The Czech pension system reforms since 1996 have led to a progressive increase in the statutory retirement age (SRA), which will reach 65 years in 2030 based on current legislation. The statutory retirement age is the normal age of opening rights to a pension. The large increase in the population aged 65 and over, by about 47% between 2000 and 2019, only induced an 18% increase in the population at or beyond the statutory retirement age. The planned increase in the statutory retirement age will continue to contain the growth in the number of potential retirees, especially among women. The number of women at or above the statutory retirement age is expected to decrease slightly between 2020 and 2030.

Figure 2. Population above the statutory retirement age by gender



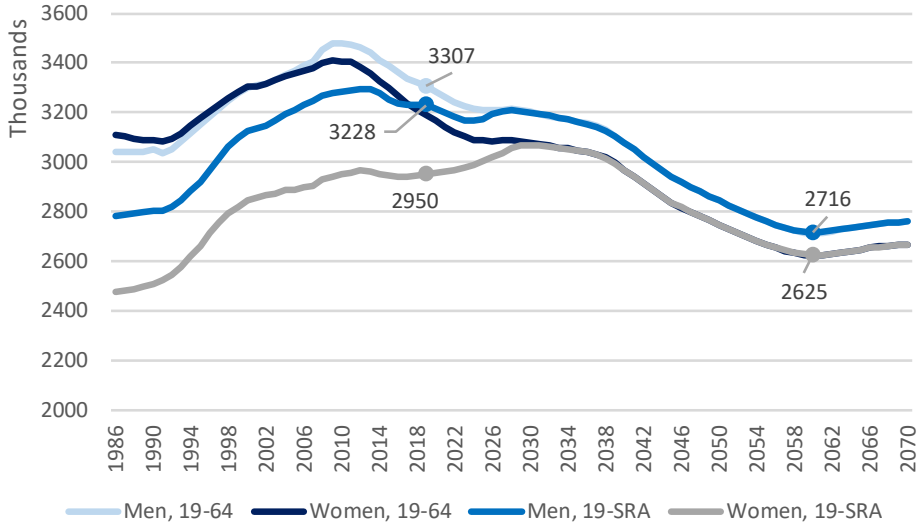
Source: Calculations from the Czech Statistical Office data.

3.2. Projections of the working age population

28. The population aged between 19 and 64 is expected to decline by 18% between 2019 and 2059 (see Figure 3). However, the working-age population, defined between 19 and the statutory retirement age, taking into account the planned increase in the statutory retirement age will remain relatively stable until 2030, before trending down slowly until 2040, and faster afterwards.

Figure 3. Projections of the working-age population

Population aged 19–64 and population below the statutory retirement age.



Source: Calculations from the Czech Statistical Office data.

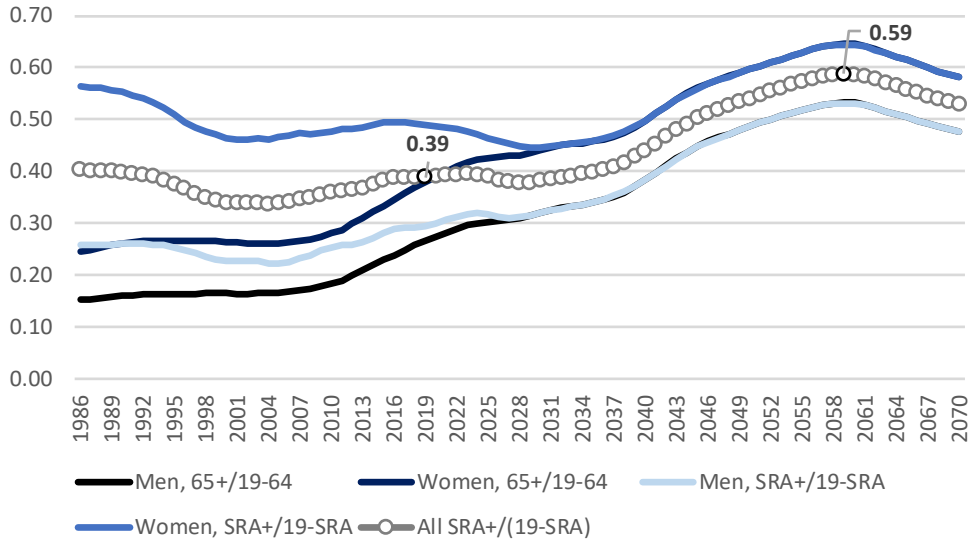
3.3. Evolution of the dependency ratio

29. One measure of the old-age dependency ratio is the ratio of the population at and over the retirement age to the working-age population (19 to retirement age). Another measure is the demographic

old-age dependency ratio based on a fixed age boundary, e.g. 65 years. The purely demographic measure has been sharply increasing. However, taking into account the increase in the statutory retirement age, the economic dependency ratio will remain stable until 2035, before increasing until the late 2050s. The dependency ratio is expected to increase from 0.39 in 2035 to 0.59 in 2060, i.e. by 50% (Figure 4).

Figure 4. The old-age dependency ratio is declining

Ratio of working-age adults to the elderly (aged over 65 or over the statutory retirement age)



Source: Calculations from the Czech Statistical Office data.

4. The macroeconomic framework

30. A long-term general equilibrium model is developed to project GDP growth (see Annex A). It is a one-sector small open-economy model with labour and capital markets and a goods market including the external market. Taxation of capital, profits and wages are taken into account. More precisely, the external sector is modelled through exports, imports and the real exchange rate equilibrium. Variations of the nominal interest rate ensure the balancing of the capital market. The capital market reacts to the mobility of capital, which depends on the differences between the real interest rates in the Czech Republic and the euro area.

31. The labour market is modelled in the form of a wage-bargaining process and a Phillips curve, which gives the reduced form of the labour market equilibrium. It takes into account the evolution of the labour force. The reactions of the model to productivity or demand shocks depend on the parameters of the wage-bargaining process, namely the slope of the Phillips curve. This slope is calibrated using the macroeconomic data from 1990 to 2019. The model is log-linear around the steady state.

32. The long-term model assumes that the economy is close to its potential. However, the dynamics of the short-run takes into account the positive output gap in the recent period and the impacts of the COVID-19 crisis. The Czech economy was overheating during recent years and therefore, the long-term unemployment rate assumed is higher than the 2018 and 2019 levels.

33. The macroeconomic equilibrium is summarised by three main variables and three principal equations (see Annex A for the precise derivation of the equations). The main price variable is the inverse of the real exchange rate q, which is defined in logarithms form as follows, where e is the nominal exchange rate, *p* the production price and p^* the foreign price.

$$q = e + p^* - p \qquad (1)$$

34. The GDP is denoted y and the nominal interest rate is denoted i. The three principal relationships are:

- The supply curve, where the GDP decreases with the real exchange rate, as all factor costs (inputs, capital and wages) tend to increase with the inverse of the real exchange rate, and the nominal interest rate *i*, which is a component of the cost of capital.

$$y = a + n^0 - \frac{1}{\gamma\phi}\left(\alpha_C q + \dot{\tau_L} + \dot{\tau_C} + \frac{1}{1-\alpha}\mu + \varpi\right) - \frac{\alpha}{1-\alpha}\left(1 + \frac{1}{\gamma\phi}\right)(\alpha_i q + \dot{\tau_C} + i - \pi + \dot{\tau_K}) \quad (2)$$

- The demand curve is increasing with the real exchange rate as the prices of consumption; investment, exports and public spending increase with the inverse of the real exchange rate, and with the nominal interest rate, which pushes up the investment cost.

$$(1 + \theta_z)y = \theta_c c^d + \theta_i inv^d + \theta_z z^d + \theta_x x + (1 - \theta_c - \theta_i - \theta_x - \theta_z)g \quad (3)$$

- The balance of payment: for which, the net flow of foreign capital offsets the difference between exports and imports. Net exports are increasing with the real exchange rate and decreasing with the nominal interest rate, which penalises imports of capital. The flow of foreign capital is an increasing function of the difference between the nominal and foreign interest rates, once taken into account the expected trend in the nominal exchange rate.

$$BC(y, q, \tau_j, i) + BK(y, q, \tau_j, i) = 0 \quad (4)$$

35. The calibration of the steady state is based on the macroeconomic evolution. Between 2010 and 2018, the Czech Republic has experienced a decline in the working-age population, which contracted by 5.2%. In the meantime, productivity gains amounted to 13.2% while real wages increased by 30.8% and the unemployment rate fell from 7.3% to 2.5%. The mark-up decreased by about 3% – the share of compensation in private value-added went from 44.3% up to 47.3%[2]. Real exports increased by 53% and real government expenditure increased by 2.7%. The minimum wage, which increased by 33% in nominal terms and 17.3% in real terms, is the proxy for the reservation wage. The capital intensity of the economy also declined by 7.5%[3]. Increases in the value-added tax are included.

36. The results of the model are sensitive to the value set for the slope of the Phillips curve[4]. In fact, the Phillips curve has probably flattened since the 1990s, as large declines in unemployment in the 2000s did not generate inflation spikes in Western economies. Moreover, the increase in the statutory retirement age may have temporarily raised participation and employment, boosting the wage bill, but at the expense of productivity.

37. The baseline scenario assumes a long-term unemployment rate of 3%. In the short-run, the baseline scenario is in line with the Ministry of Finance's short-term macroeconomic forecasts (MoF, April 2020). Productivity growth is set at 1.5% over the long run. The productivity growth assumption is lower than the one used in the EU Ageing report of 2018[5] (EU, 2018). From 2022, the active population is assumed to move in parallel with the working-age population as the effects of the increase in the statutory retirement age on senior participation would remain minimal. Foreign demand is supposed to grow at 1.2% and public spending would grow in line with GDP. The reservation wage (minimum wage) is projected to

[2] The productivity of self-employed is assumed to be 40% of the productivity of employees, in accordance with remunerations from the SILC surveys, once taken into account gender, age, education, economic sector, hours worked, number of months worked and years.

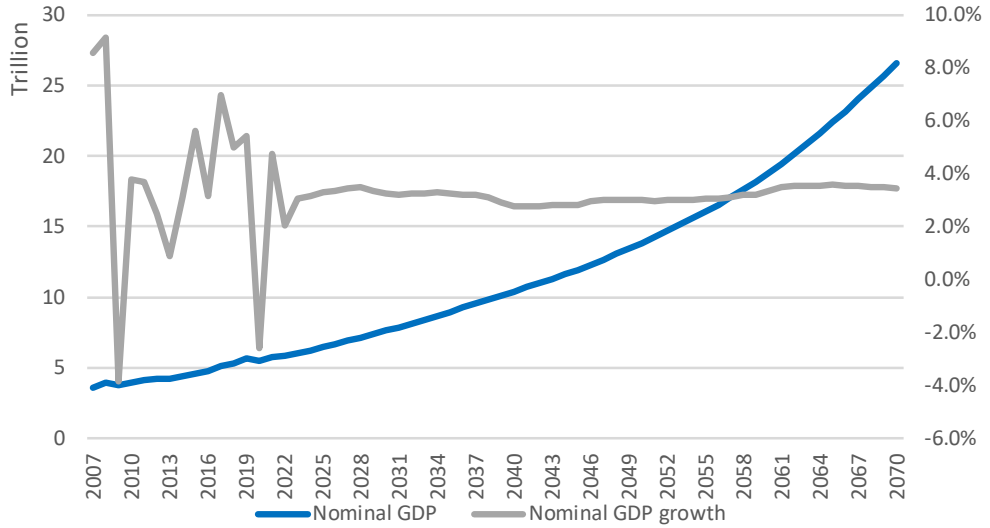
[3] Given the huge increase in real wages in recent years, this change is probably not structural.

[4] See Annex A. for a discussion of the features of the Phillips's curve and assumptions made for the projection.

[5] The report was foreseeing a total factor productivity (TFP) growth of 1.2% plus 0.6% of capital deepening, that is 1.8% in total. We do not consider capital deepening in the macroeconomic framework so a higher value for the TFP growth is used as a compromise, that is 1.5%.

move with productivity. Inflation is flat and equals to 2% per year[6]. Over the projection period, nominal GDP growth is projected to oscillate between 2.3% and 3.3% per year (Figure 5).

Figure 5. Long-term projection of GDP



Source: The simulation model.

5. A cohort model to project careers and the accumulation of pension rights

38. The cohort model simulates the career path of a sample of representative workers from age 19 to the statutory retirement age. For each individual, participation in the labour market is determined, then the employment or unemployment status is drawn and finally, for active and employed workers, the wage level is determined. The model also determines the contribution periods validated taking into account education, unemployment periods and the number of children for women. Disability status is also determined based on projections of disability probabilities using recent trends. To increase the accuracy of the status in the labour market, projections take into account the level of education by gender.

5.1. Projections of labour market participation

5.1.1. Participation by age group and education level

39. Participation rates by age and level of education are estimated based on SILC surveys. These estimated participation rates are used in the cohort model to determine individuals' participation in the labour market. Participation in the labour market is affected by (partial) disability status and pensioner status (old-age or survivor benefits). To compute the participation rates of individuals by age group and education level, Eurostat data are used to calculate the number of retirees and (partially) disabled individuals participating in the labour market.

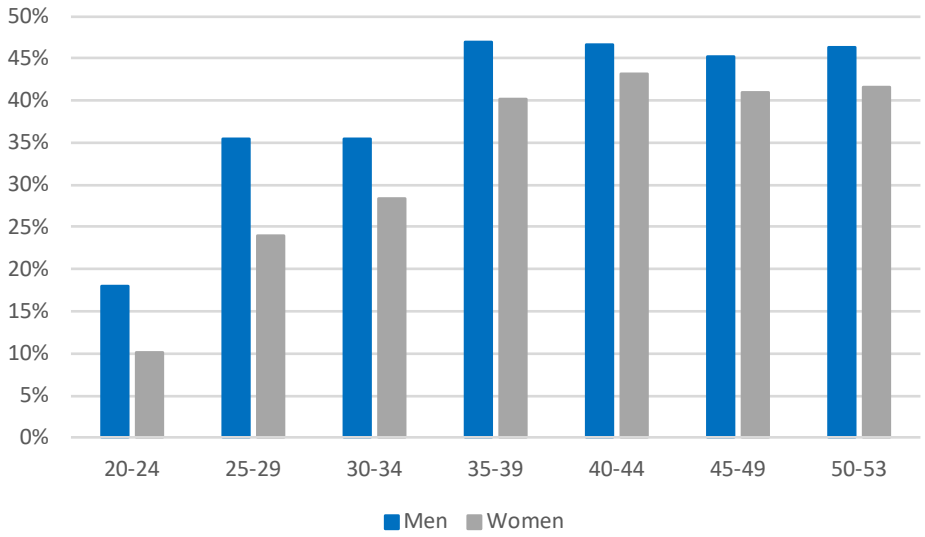
40. The number of disabled and retirees by education level is not published by the Czech Social Security Administration but can be gauged from the SILC surveys. The probability of being disabled varies significantly with education. On average people with upper secondary education are about 40% to 45% less likely to be disabled than people with primary or lower secondary education; while people with tertiary education are as much as five to six times less likely to be disabled. These ranges are significantly lower

[6] As revenues and spending of the pension system are displayed as a share of nominal GDP, assumptions on the inflation rate do not bear any impact on the results.

for women after age 55. Women with tertiary education above age 45 are indeed 70% less likely to become disabled than women with primary or lower secondary education. These relative probabilities between education groups are stable across time and age groups, allowing disentangling between different education levels the numbers of disabled.

41. The share of disability pensioners participating in the labour market is significant. Figure 6 shows the share of people below 55 who claim participating in the labour market while receiving a disability pension in the SILC surveys. This share has been steadily increasing between 2005 and 2018, reaching 43% of men and 39% of women receiving a disability benefits, according to the SILC surveys. It increases with age, from 10% to 18% for women and men around the age of 20, respectively, before plateauing at 41% and 45% for women and men, respectively.

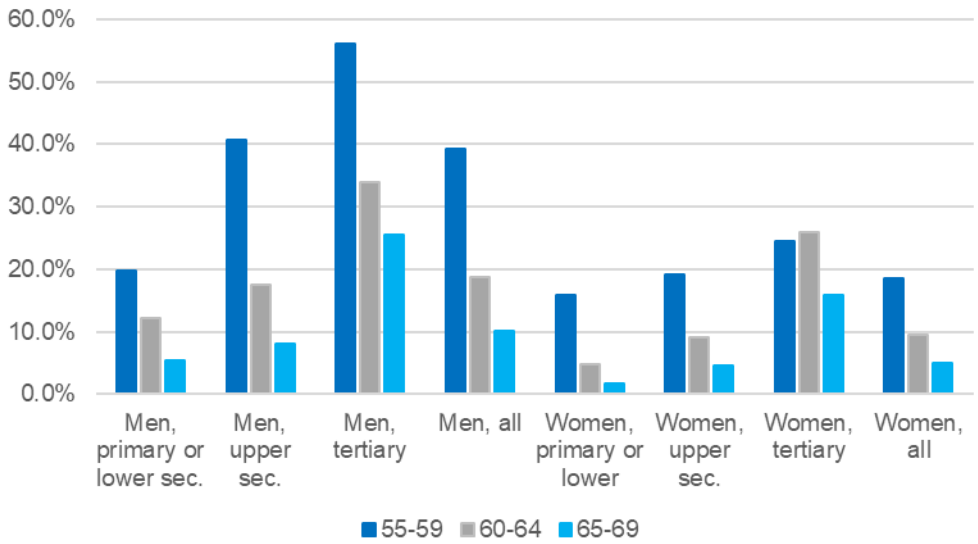
Figure 6. Share of recipients of disability benefits participating in the labour market
2005–2018 by age group and gender.



Source: Calculations from SILC data.

42. Participation rates after age 55 suggest that many old-age retirees are still participating in the labour market. As pointed out by SILC data (see Figure 7), about 19% of men and 10% of women who are already pensioners are still participating in the labour market between ages 60 and 64. In 2018, about 16% of women with tertiary education between ages 65 and 69 were still in the labour market while this rate is at 25% for men. Although these senior workers only represent less than 2% of the workforce at present, this population is expected to increase, as the share of tertiary graduates in the younger population is high.

Figure 7. Share of pensioners participating in the labour market, 2005–2018



Note: SILC data does not allow disentangling by pension types (old age versus survivor).
Source: Calculations from SILC data.

43. The participation rate of the group of people *i* during year *t* who are neither disabled nor old-age pensioners, nor survivor pensioners is denoted a_t^i. These groups allow differentiating participation by gender, age and education level. We assume that a share α_D^i of people with disability pensions in this group are participating and that a share α_R^i of people in the group already retired are also participating. The participation rate in this group can be computed as follows, with N_t^i the total population of the group, A_t^i the number of active people and D_t^i and R_t^i respectively the number of disabled and retirees in this group *i*.

$$a_t^i = \frac{A_t^i - \alpha_D^i D_t^i - \alpha_R^i R_t^i}{N_t^i - D_t^i - R_t^i} \qquad (5)$$

44. Participation rates are close to 100% for males with at least upper secondary education from the ages of 30 to 50. Participation rates for women with similar education levels between ages 40 and 55 are also above 90%. However, other factors are affecting the determination of participation rates.

5.1.2. Maternity leave and women's participation rates before age 45

45. The Czech Republic has one of the most educated female labour forces in the EU. In 2018, 94% of young women from ages 21 to 39 had at least completed upper secondary education. This is the third-highest rate in the European Union and is well above the EU average of 86%. Young men of this age group are participating strongly in the labour market, also well above the EU average. The participation of young women in the labour market is, however, rather low (around 66%), well below the EU average of 72%. Therefore, the gender participation gap is the largest in the EU, at 25 percentage points, about 2.5 pp. larger than in the EU as a whole.

46. Integration to the labour market is delayed for women due to maternity for all levels of education. Like men, women who are more educated tend to enter the labour market later but do participate more once in. Female participation decreases between early years and age 40, corresponding to maternity years. The gender participation gap is the difference in participation rates between men and women at a given age and level of education. The gap increases at early ages for less educated women, consistent with the fact that they tend to give birth younger (In the cohort model, the labour force participation of women is estimated using an age profile, which depends on the education level. The years of maternity

are then drawn randomly following age-specific fertility rates. Women are not participating during their maternity leave but are still validating contribution periods.

47. After taking into account the labour market participation of retirees and disability pensioners and the impact of maternity leaves, the participation of the remaining workers appears high (Figure 9). It is close to 100% for men with upper secondary or tertiary education between the ages of 30 to 60. Participation in the labour market tends to increase smoothly as young men progressively enter the labour market after graduation. This integration period is shorter for less-educated men, while the final level of participation tends to increase with education levels.

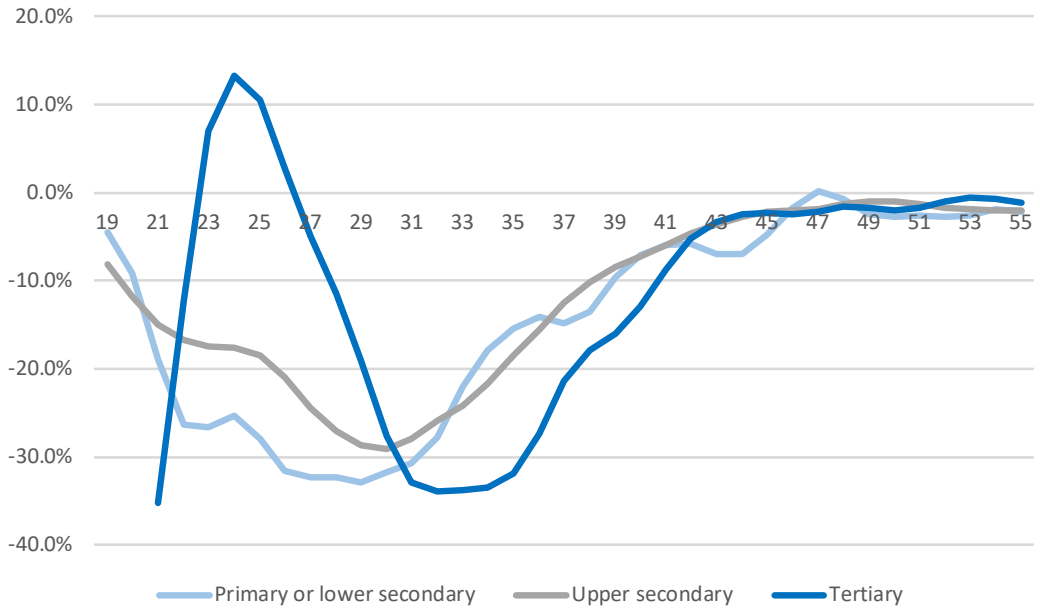
48. Figure 8). The gap closes at around age 43, which corresponds to four years[7] after the likely last birth. The gap is positive for university graduates between ages 23 and 26, as young women tend to graduate earlier than men and enter the labour market more rapidly. It then falls rapidly from ages 27 to 35 corresponding to the first maternity. Aggregating the gap from ages 19 to 43 and dividing by the total fertility rate indicates that on average, women take between 2.1 and 2.4 years off the labour market for every child born.

49. In the cohort model, the labour force participation of women is estimated using an age profile, which depends on the education level. The years of maternity are then drawn randomly following age-specific fertility rates. Women are not participating during their maternity leave but are still validating contribution periods.

50. After taking into account the labour market participation of retirees and disability pensioners and the impact of maternity leaves, the participation of the remaining workers appears high (Figure 9). It is close to 100% for men with upper secondary or tertiary education between the ages of 30 to 60. Participation in the labour market tends to increase smoothly as young men progressively enter the labour market after graduation. This integration period is shorter for less-educated men, while the final level of participation tends to increase with education levels.

Figure 8. Inferred gender gap in participation rates

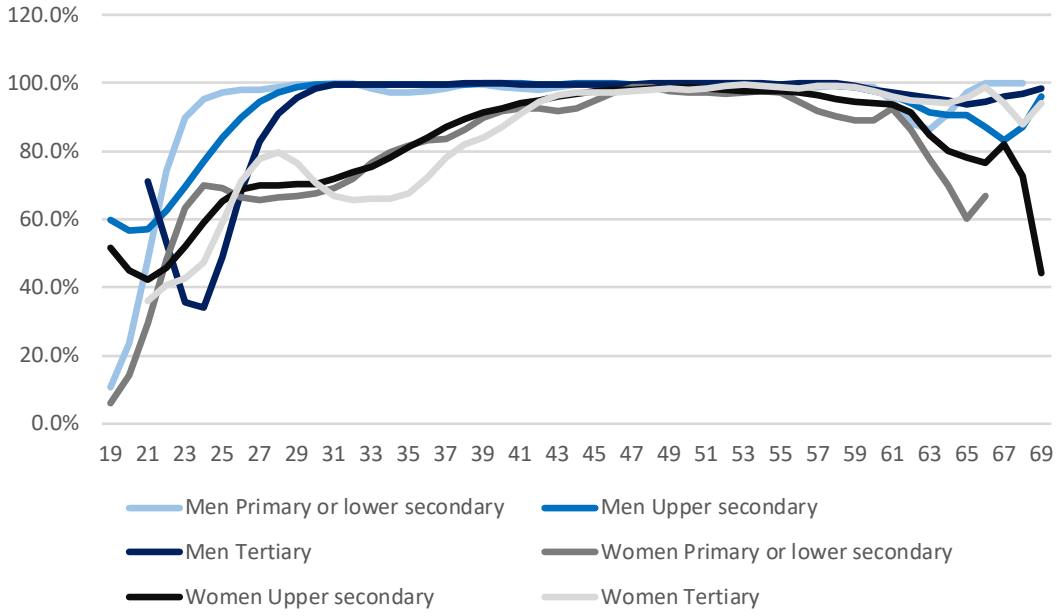
Gender participation gap by education levels and age.



Source: Calculations from SILC, Eurostat and the Czech Social Security Administration data.

7 The legal maximum parental leave is four years.

Figure 9. Average participation rate by education and age
Averaged over 2006–2018, for non-pensioners.



Source: Calculations from SILC, Eurostat and the Czech Social Security Administration data.

5.1.3. Migration

51. Migration matters for pension projections mainly through its impact on both the future workforce and the number of pensioners. The share of the Czech population emigrating each year has been stabilising at around 0.17% in the last five years. It never went above 0.35% in the early 2000s.

52. Immigration before the age of 19 is not taken into account, as the number of younger immigrants is already embedded in the official demographic projections. The rate of immigrants among people aged 65 and more is currently below 0.03% per year. It is therefore possible to neglect immigration of pensioners in the model. The distribution of working-age immigrants by age is forecasted using the average entry numbers from the past years, according to official data.

5.2. Modelling of careers and wage distribution

53. The model simulates the career of individuals from the age of 19 to 69, with one observation per year, for labour market participation, unemployment, disability status, self-employment status and wage. More precisely, if an individual is active in the labour market, first his/her status (salaried employee or self-employed) is drawn. If he/she is a salaried worker, then whether he/she is unemployed or not is drawn. If he/she is working, then his wage is determined.

5.2.1. The determination of individual wages

54. Wages are drawn randomly with their level depending on age, gender, disability status and education. A "Mincerian" equation is estimated using SILC data to set the parameters of the wage level (equation 6). The age profiles are denoted by α_a^s, with *s* being either male or female, education level is denoted e^i and can be primary and lower secondary, or upper secondary and tertiary. Wages are also a function of age *a*, gender *s*, disability status *d* and self-employment status *f*. There is a time trend η_t and an idiosyncratic shock ε_t^i, which is auto-correlated to describe the transition of individuals across the

hierarchy of wages. As expected, all other things equal, people with disabilities and self-employed workers tend to have lower wages than employees.

$$\ln W_t^{s,i} = \alpha_a^s a^i + \gamma_e^s e^i + \delta d^i + \theta f^i + \eta_t + \sigma \varepsilon_t^i \qquad (6)$$

55. The time trend η_t is computed such that the yearly average nominal wage growth follows the macroeconomic trend, which is deduced from the simulation of the macroeconomic framework. The idiosyncratic auto-correlation shock is estimated from SILC (equation 7).

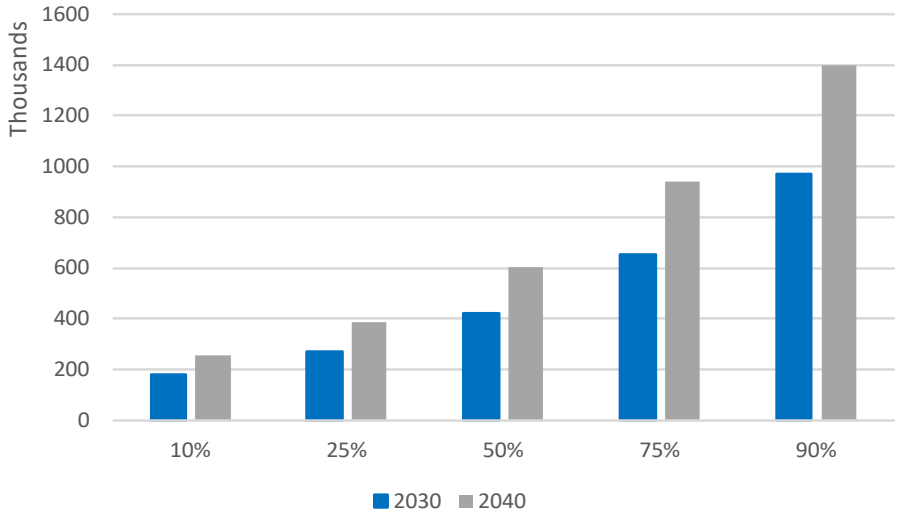
$$\varepsilon_t^i = \rho \varepsilon_{t-1}^i + \sqrt{1-\rho^2}\epsilon_t^i \qquad (7)$$

56. The standard deviation σ is calibrated to fit the overall distribution of wages according to the values of quantiles released by the Czech Statistical Office. Potential asymmetries in the idiosyncratic shock have been determined using a two-piece normal distribution. However, the two half-standard deviations around the mean are statistically similar in the recent years, justifying this simplified modelling choice.

57. The simulated wage distribution takes into account differences linked to individual characteristics, and reproduces wage inequalities (Figure 10).

Figure 10. The simulated wage distribution

Annual wages by quantile, in Czech koruna.



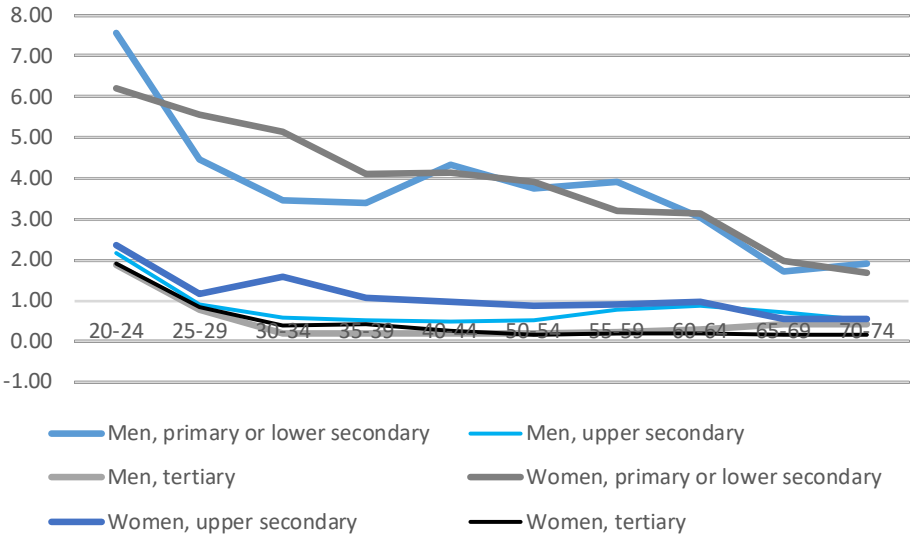
Source: Simulations from the cohort model.

5.2.2. The inclusion of unemployment periods in the career

58. The unemployment status is drawn randomly taking into account education level, gender and time auto-correlation. Unemployment has remained low in international comparison since the early 1990s in the Czech Republic. It was historically low at around 2% on average in 2019, before the Covid-19 pandemic. However, youth is facing some periods of unemployment when transitioning from school to the labour market. Over the last 15 years, unemployment at a given age has remained proportional to the average unemployment rate. This feature allows computing a typical age profile of unemployment rates, which will be translated up and down following the overall situation of the labour market. Female and male unemployment do not differ much in their features, although young women tend to enter faster the labour market while they converge to the same employment level as men in later life (Figure 11).

Figure 11. Age profile of the unemployment rate by education level and gender

Ratio of the unemployment rate to the average unemployment rate by education level and gender, average 2005–2018.



Source: Calculations from SILC data.

5.3. Validation of contribution periods

5.3.1. The different sources to validate pension insurance periods

59. There are four main sources of validation of contribution periods in the pension system. Firstly, employees and self-employed workers paying social contributions validate these periods as pension insurance periods.

60. Secondly, contribution periods are accrued for education before 2009. Different rules are applied depending on the years and the level of education. Time in secondary education, between ages 15 and 17, taken before 1995 is 100% validated (i.e. every student has 3 years of insurance). For education periods between 1996 and 2009 (included), a maximum of 6 years of periods of (secondary or tertiary) education is 80% validated for students of 18 years or older. For education periods after 2009, no contribution periods are granted. Therefore, the generations born after 1986 will have no education periods validated as contribution periods.

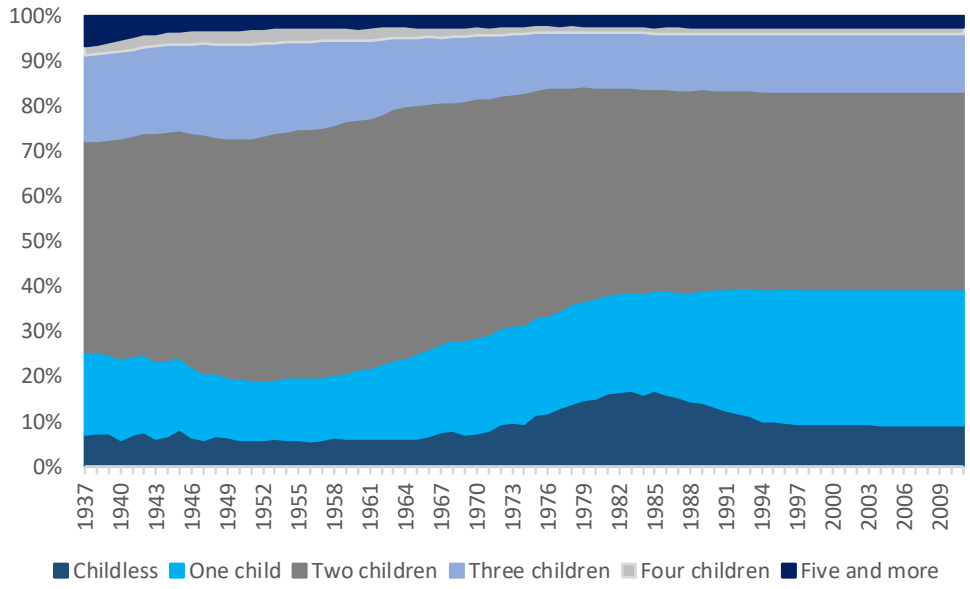
61. Thirdly, unemployed people covered by unemployment insurance validate 80% of their unemployment period (below one year) on a monthly basis. Because the cohort model is structured on a yearly rather than a monthly basis, one has to approximate the current validation rule. In the model, unemployed people are assumed to be covered as long as they were working the previous year. In that case, their contribution period is increased by 0.8 years. Also, a maximum of one year of unemployment without unemployment benefits can be validated before age 55 and an additional two years can be validated for unemployment after age 55 without unemployment benefits.

62. Finally, women validate insurance periods for maternity and parental leaves. The current number of children per women is about 1.71. According to official projections, the fertility rate will converge to 1.74 in the long-run, assuming that fertility among young women will continue rising at the rate observed during the last eight years for another eight years before stabilising. The distribution of the number of children per women for future generations is therefore projected by adding a quadratic term ensuring that age-specific

fertility rates by birth order converge by 2024[8] (Figure 12). The projected number of children per woman is used to determine the duration of maternity/parental leaves and these periods are accrued as validated contribution periods. The number of children per women is drawn randomly depending on the education level. Women get two years in a row of validated contribution periods for each maternity/parental leave.

63. The final source of validated contribution periods is the partial or full disability status. The model records these statuses for all individuals from ages 19 to 69, to ensure that each year cannot be validated more than once.

Figure 12. Distribution of women by cohorts and number of children in their lifetime



Note: Projections using quadratic convergence of fertility trends in the past eight years.
Source data from the Human Fertility database.

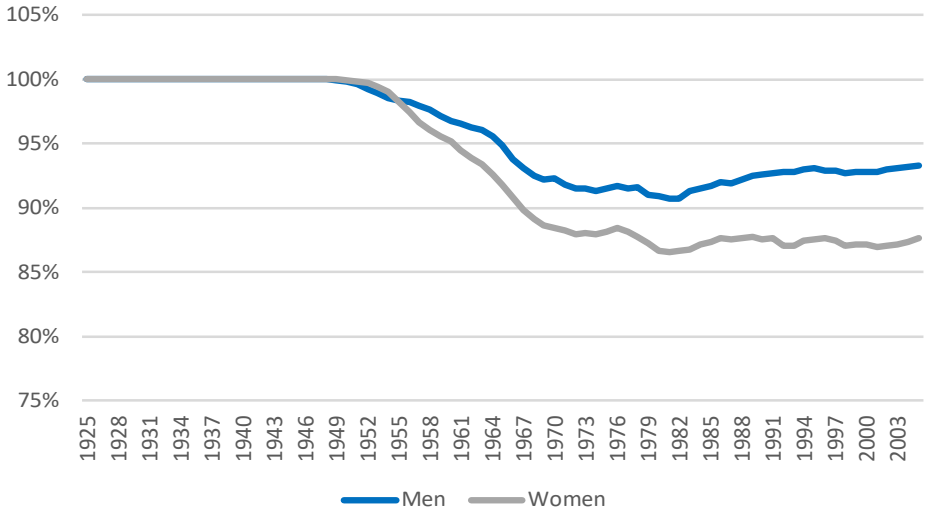
5.3.2. The evolution of the average insured period

64. The insurance period to be eligible to a pension is to have contributed 30 years or validated 35 years of contributions. It means that an individual who has not been paying a contribution for 30 years needs to have at least 35 years of contribution periods when including insurance periods validated for education, uninsured unemployment periods or parental leave for women.

65. Up to now, this condition does not seem to have prevented many individuals to be entitled to a pension at statutory retirement age (SRA). However, the simulations indicate that among the young generations, 6% of men and 12% of women will not be eligible for an old-age pension when they reach the SRA (Figure 13).

[8] Such forecast is necessary to project the participation rates of women in the decades to come and therefore their pension contributions and pension entitlements.

Figure 13. Share of a generation fulfilling the required contribution period at statutory retirement age



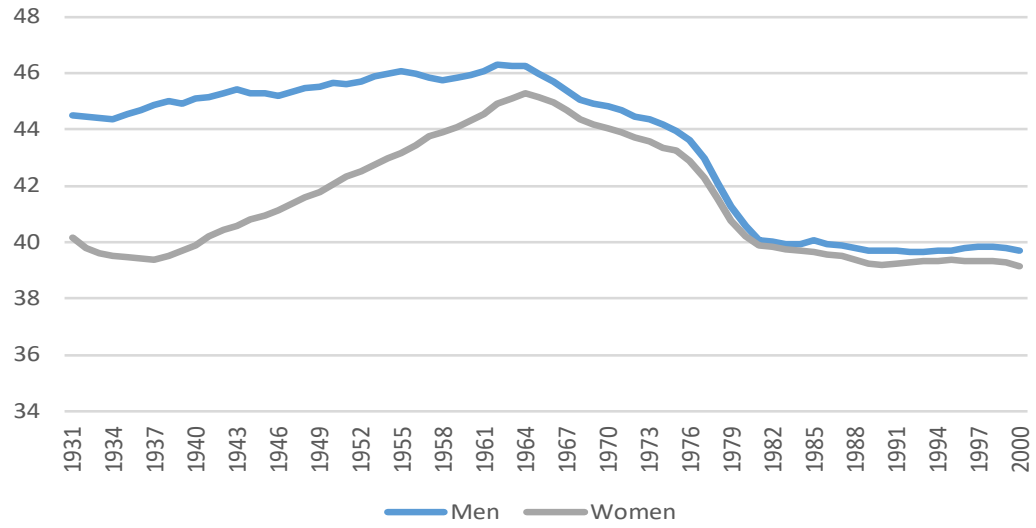
Source: Simulations from the cohort model.

66. Figure 14 confirms that generations arriving at retirement age from 2025 will have on average validated fewer contribution periods than previous generations. More precisely, generations born between 1940 and 1965 were affected by an increase of the retirement age by 5 years for men and around 10 years for women. This increase in the retirement age is reflected in the increase of the average contribution period, in particular for women. From generations born in the 1970s, the average contribution period decreases progressively for men and women, reflecting mainly changes in the labour market and the fact that these generations are the first ones having their entire careers in the market economy. There is a second shift toward lower contribution periods from generations born from the 1980s also reflecting longer education periods and from the 1986 generation that education periods are not accrued in the insurance period any longer.

67. However, different factors are at play to explain the evolution of the average contribution period including not only changes in retirement age and accrual of education periods but also later entry in the labour market, evolution of the unemployment rate and changes in labour participation.

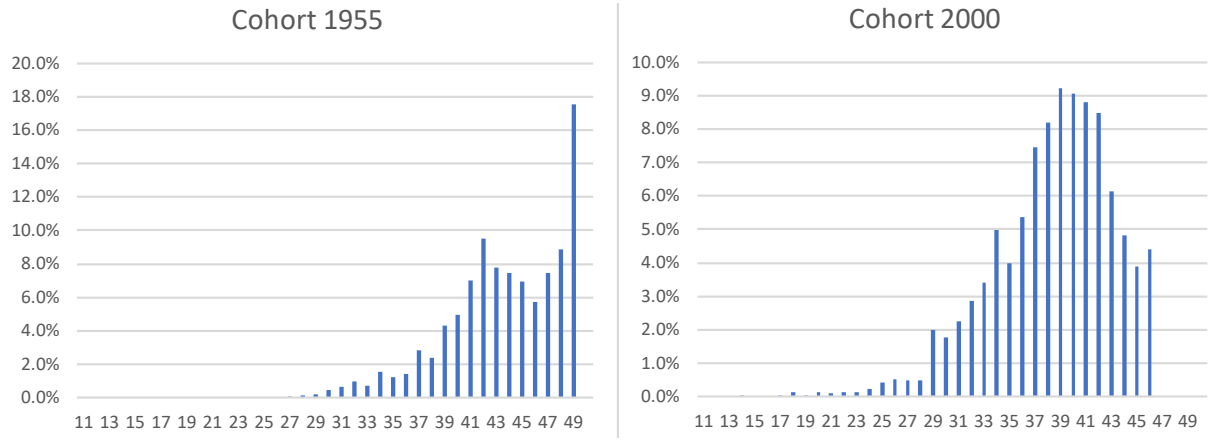
68. The comparison of the distribution of the number of contributed periods for different generations shows the shift in the number of contribution periods validated and the development of shorter careers across time. For instance, in Figure 14, for the cohort born in 2000, none has a career of 48 or 49 years compared to between 9% and 18% for the cohort born in 1955. The impact of education is also seen in the distribution as there is a shift to the left but also denser distribution around 40 years of validated years of contribution.

Figure 14. The projected evolution of the average validated contribution period
At statutory retirement age by birth cohort.



Source: Simulations from the cohort model.

Figure 15. Distribution of the number of contribution periods at statutory retirement age

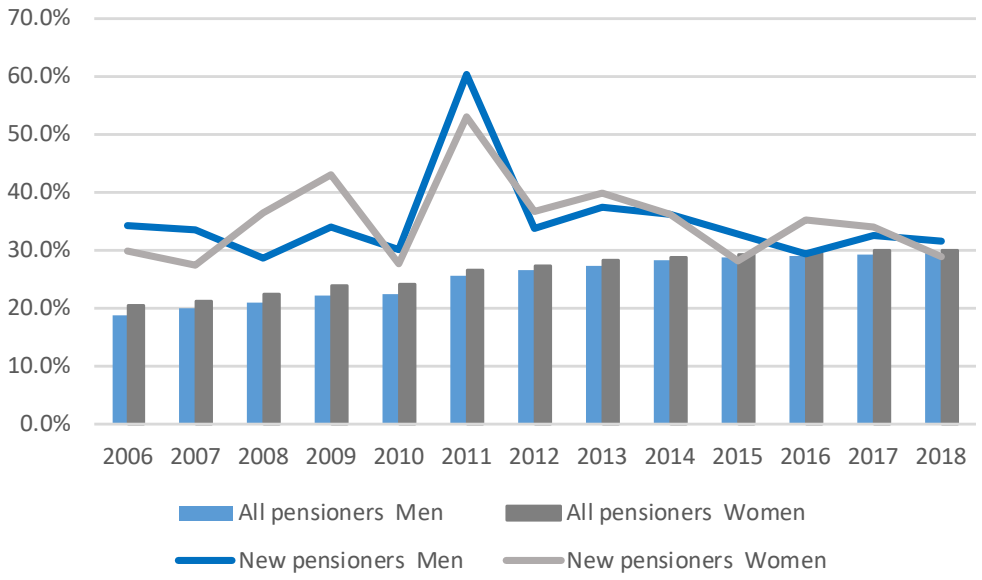


Source: Simulations from the cohort model.

5.4. Retirement decisions

69. Firstly, the use of early retirement (retirement before statutory retirement age) has increased a little, but the duration of early retirement (distance to normal retirement age) is becoming shorter. In 2018, about 30% of all old-age pensioners retired before the statutory retirement age. This share has increased from 20% in 2006 as the number of early retirees among new pensioners rose sharply between 2006 and 2011 before stabilising at around 30% (Figure 16). However, the length of early retirement has been almost halved for men, from about 2 years in 2006 to 1.1 years in 2018. In 2006, the proportion of early retirees leaving within a year prior to retirement age was negligible, while it now represents about a third of new early retirees among men. The average length of early retirement decreased less for women, going from 2.1 years in 2006 to 1.6 years in 2018. The share of early pensioners retiring within the statutory retirement year (for their generation) increased from 23% to 31% among women.

Figure 16. Share of early retirement among new and all pensioners



Source: Calculations from the Czech Social Security Administration data.

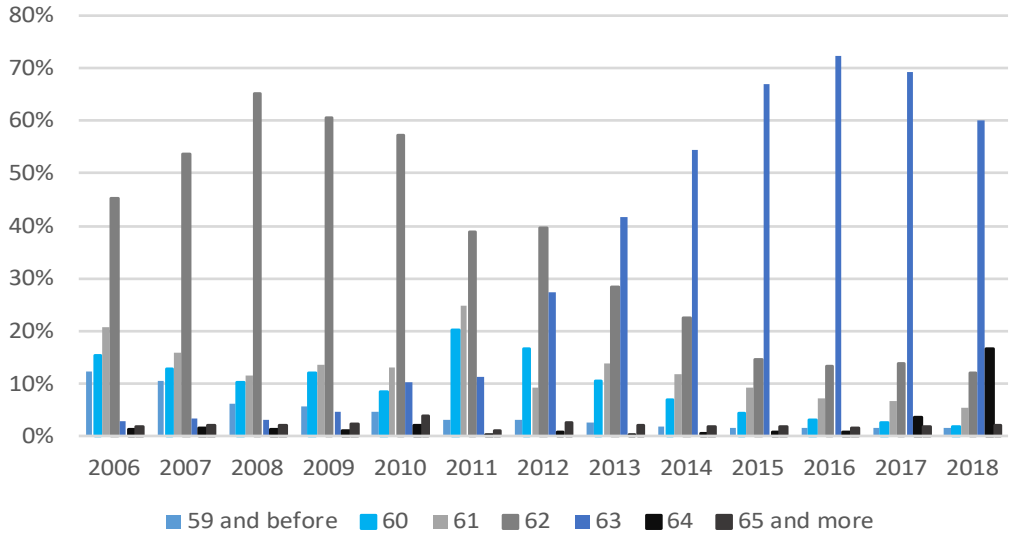
70. Secondly, delaying retirement after statutory retirement age is rare in the Czech Republic. In 2018, fewer than 300 people entered the pension system as late retirees, representing only 0.4% of all new old-age pensions. Social Security Administration data confirm that Czech citizens massively retire within the year of their statutory retirement age. In 2010, the SRA was 62 years and more than 55% of men retired within that age, while by 2018, the SRA had increased to 63 years and a similar share of the new retirees were about that age (Figure 17).

71. Thirdly, the distribution of age at retirement among men has also become significantly more concentrated. In 2006, about two third of men were retiring either at their SRA or one year earlier. This share is now higher than 80%[9]. The picture is more complicated for women, as the statutory retirement age depends on the number of children, so it is not possible to compute precisely the share of new pensioners in relation to their personal SRA. However, there was a rapid adjustment in the retirement age in the period during which the SRA increased. In 2006, about 40% of new female pensioners retired at 58 while in 2018 there were less than 2% who retired at that age while almost half of new pensioners retired at 61.

[9] The standard deviation in the retirement age has decreased by 25% from 2006 to 2018, from 1.7 years to 1.2 years.

Figure 17. Distribution of age at retirement for new male old-age pensioners

Share of new male old-age pensioners by age at retirement.



Source: Czech Social Security data.

72. Using the cohort model, one can simulate the share of men in a generation who could have been eligible for early retirement, up to three years before the statutory retirement age. The eligibility criteria is having completed the mandatory contribution period. The rates of eligibility for early retirement are still high, ranging from 95.6% three years prior to statutory retirement age to 97.7% within the SRA in 2018. The mandatory contribution period does not represent yet a binding constraint for pre-retirement. After a peak in 2011, following the reform, the distribution of early leavers among those who were eligible for early retirement has remained quite stable.

73. Therefore, it seems reasonable to assume that the share of early leavers will remain constant in the future. The share of early retirees is likely to remain about a third of those who are entitled to it, in line with current observations.

74. The retirement decision rule is therefore a behavioural rule. It is assumed that individuals, once satisfying the mandatory contribution requirement reproduce past behaviours and mainly retire within the year of the statutory retirement age.

6. Projections of the different pension schemes

75. The mandatory pension system has three components: the old-age, the disability and the survivor schemes. The disability scheme is split in three categories: the full or third degree category and the partial or first and second degree categories. The survivor scheme can be cumulated with all the other types of pensions (Figure 18). The Czech Social Security Administration data report numbers for the beneficiaries of old-age and disability pensions who do not receive survivor pensions on the one hand and, on the other hand, for all those who have a survivor pension. Individuals cannot cumulate old-age and disability pensions. Therefore, the total number of pensioners is the sum of all categories.

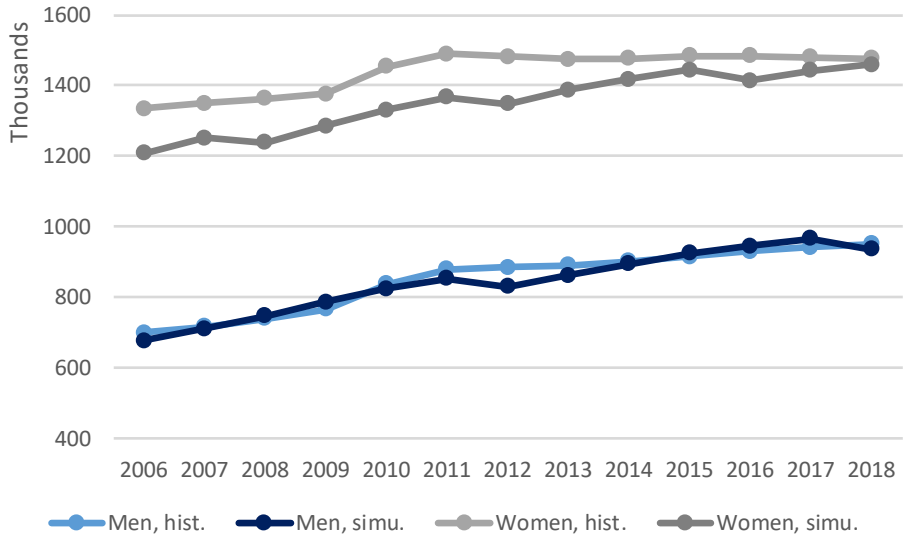
Figure 18. Typology of pensions

6.1. Projections for the old-age scheme

6.1.1. Number of old-age pensioners

76. The number of old-age pensioners is simulated using the current set of rules, but taking into account the changes in the statutory retirement age. In the simulation, people first randomly choose when they would retire, up to three years before their SRA. The retirement decision follows the observed behaviour where individuals on average retire when they satisfy the required contribution period and statutory retirement age. Therefore, individuals retire as soon as they either complete the mandatory contribution period or 5 years after the SRA. This set of rules has been tightened in recent reforms which may explain why a gap remains between the simulated and the historical figures, especially for women, around the reform year of 2011 (Figure 19). The simulation, however, correctly matches overall trends and the orders of magnitude of the numbers of old-pensioners. For the year 2018, the number of old-age pensioners is about 1.5% below historical figures for men and women. It is therefore likely that the set of rules used in the projection will lead to more accurate forecasts in the future, as the rules for early retirement have been tightened.

Figure 19. Comparison between actual and simulated number of old-age pensioners

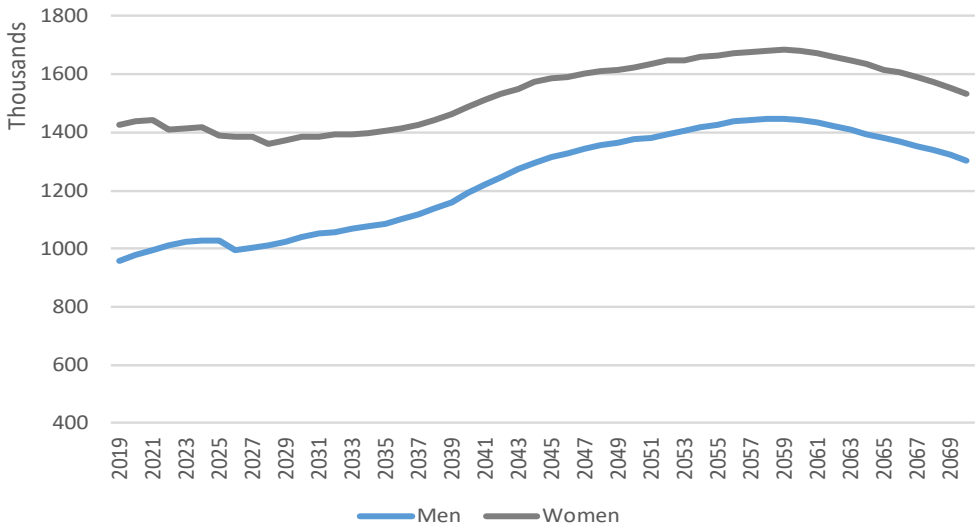


Source: Czech Social Security Administration data and cohort model.

77. The cohort model is then used to project the number of old-age pensioners up to 2070. As expected, given demographic trends, the number of old-age pensioners will peak by 2060, about 30% above the level of 2020. This increase will be more pronounced for men (+ 36%) than for women (+7.5%) (Figure 20). The number of old-age pensioners is expected to rise above 3 million by 2060. It will not

increase significantly in the coming decade as the retirement age is increasing, but will start growing in the 2030s and will accelerate during the 2040s.

Figure 20. Projection of the number of old-age pensioners



Source: Simulations from the cohort model.

6.1.2. Old-age spending

78. The pension spending is computed by calculating for each retiring individual the pension benefit by applying the pension formula (Box 1). The aggregate pension spending is given by adding newly granted pensions to previous year pensions increased with the indexation rule and taking into account mortality.

Box 1. Pension formula

The pension benefit formula is complex as it includes individual components and all-economy variables. Equation (8) gives the pension as the sum of the flat-rate component and the earnings-related component. The flat rate component is equal to 10% of the average wage (equation 9). The earnings-related component gives 1.5% of the reference wage for each service year (equation 10).

To calculate the reference wage, a very progressive formula is used under which income thresholds are applied. Up to the threshold (rb_1) of CZK 14 388 in 2019, the wage is fully taken into account. Between this threshold and the pensionable-earnings cap (rb_2) of CZK 130 796, only 26% of the wage is taken into account (equation 10). Earnings over the cap are not taken into account.

The reference wage is the average of individual earnings over the career with past earnings uprated with an index of the growth rate of the economy-wide average wage (equation 11).

$$pens = frc + erc \qquad (8)$$

$$frc = 10\% * \bar{W} \qquad (9)$$

$$erc = \left\{ \begin{matrix} \min(RW, rb1) * rc1 \\ + \max[\min(RW - rb1, rb2 - rb1), 0] * rc2 \\ + \max[RW - rb2, 0] * rc3 \end{matrix} \right\} * cpr * ar \qquad (10)$$

$$RW = \frac{\sum_{y=T-1-\min(nyc,T-1-1986)}^{T-1} W_y * \prod_{t=y}^{T-1} \frac{\bar{W}_{t+1}}{\bar{W}_t}}{\min(nyc, T-1-1986) - ncp} \qquad (11)$$

Where :

frc: flat rate component; $\bar{W}$: $average\ wage$

Erc: earnings related component; RW: reference wage

rb reduction brackets: rb1 =44%$\bar{W}$ and rb2= 400% $\bar{W}$

rc reduction coefficient, currently rc1 = 100% up to rb1, rc2 = 26% up to rb2,

cpr contribution period up to the statutory retirement age in years (including non-contributory periods assessed as if contributory but only up to certain contributory period rate with an 80% coefficient),

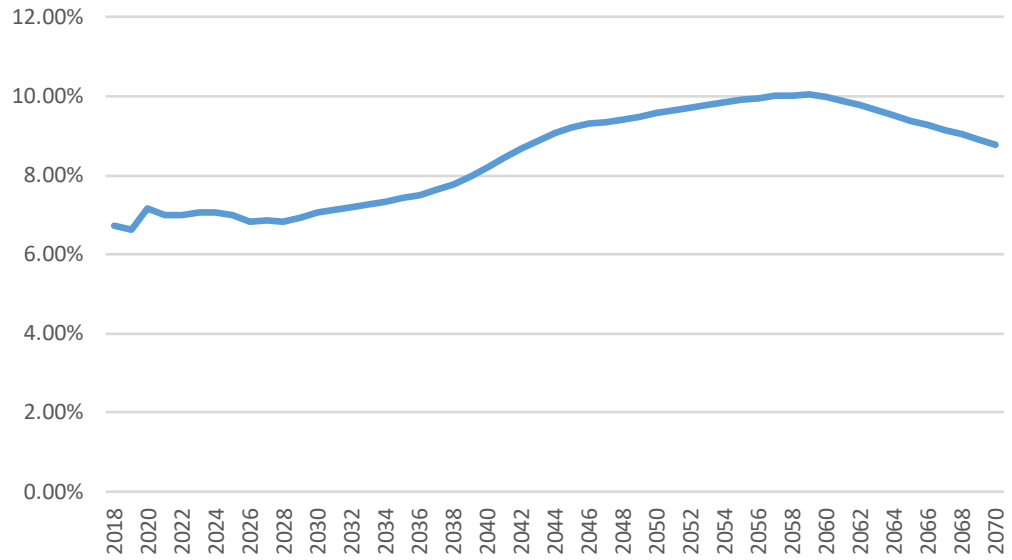
ar accrual rate: 1.5%; nyc: number of years of career,

T: year of retirement; W: yearly wage and ncp is for excluded non-contributory periods.

Source: The methodology of pension projections, Czech Ministry of Finance, 2017.

79. Old-age pension spending is projected to be stable until 2030 as the retirement age is increasing and the number of pensioners is stable. From 2030, old-age pension spending will increase steadily and peak at 10% of GDP in 2059 (Figure 21). From 2060, the decline in the validated contribution period is likely to push down spending, along with the decline in the number of pensioners.

Figure 21. Evolution of old-age pension spending in % of GDP

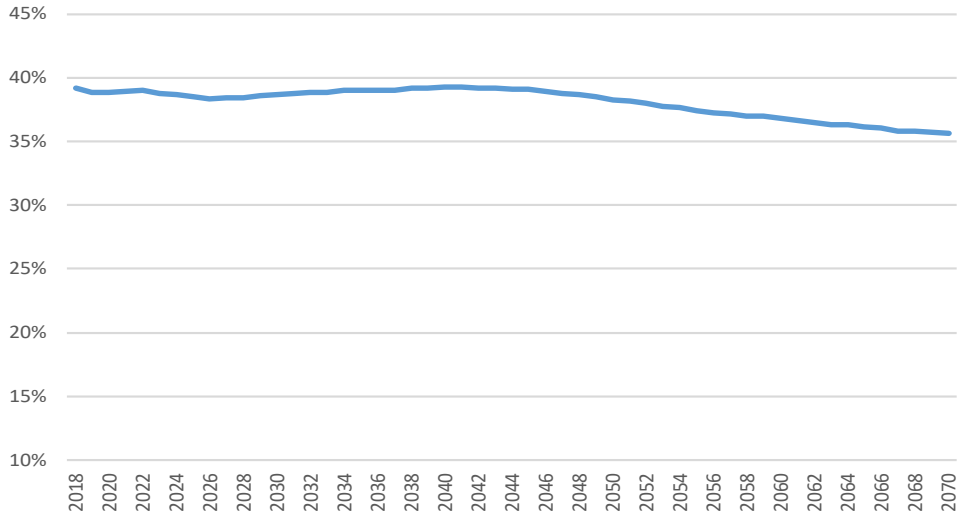


Source: Simulations from the cohort model.

80. The old-age pension benefit ratio is the average of all pensions in payment to the economy-wide average wage. It is projected to decrease steadily from 2045 as bigger cohorts enter in retirement and live longer while the accumulated gap between wage growth and pension indexation widens (Figure 22). Indeed, pensions in payment are indexed with inflation and half of the average wage growth.

Figure 22. The average old-age pension benefit ratio

The average of all pensions in payment to the average wage (%)



Source: Simulations from the cohort model.

6.2. Projections for the disability scheme

81. There are three disability categories. Persons whose working capacity has declined by at least 35% but not more than 49% form the first degree of disability; the second degree of disability corresponds to a decline of at least 50% but not more than 69%; and the third degree of disability, a decline of at least 70%, is the full disability. The required insurance period is at least 5 years.

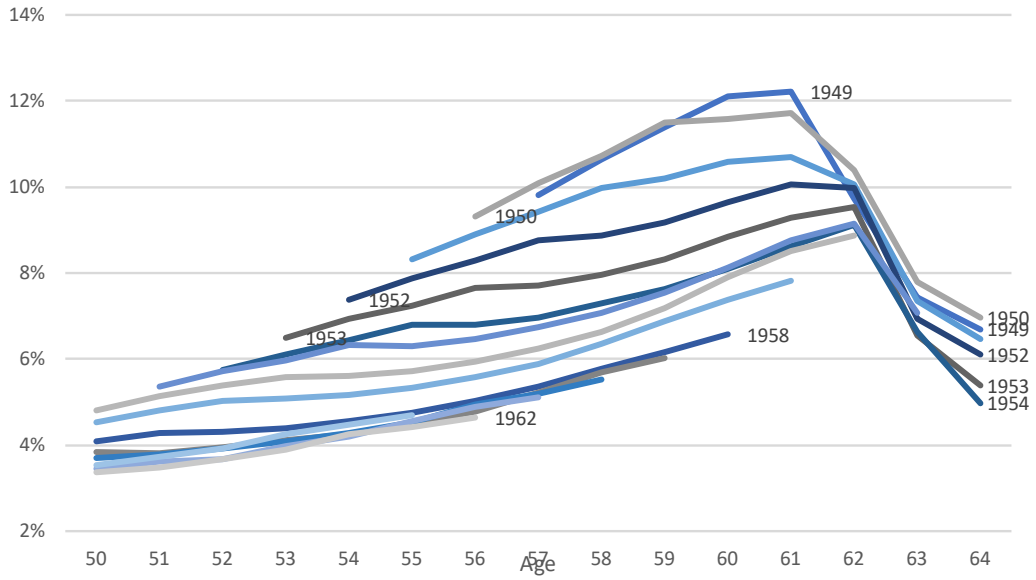
6.2.1. Full disability

82. The share of people with disability status at a given age has fallen in the second half of the 20th century. About 12% of the generation born in 1949 were receiving a full disability pension at the age of 60, while this rate is only about 6.5% for the generation born in 1958 (Figure 23).

83. However, progress has been limited for recent generations. Disability rates have decreased less after age 62 than they have for the generations born in the 1950s. The full disability rate among males went from 7.3% in the generation born in 1950 to 6.6% in the generation born in 1964 at the age of 63, while the drop was three times larger at the age of 61. Given the latest trend, the share of men claiming full disability beyond age 60 is still likely to drop significantly in the coming years, compared to the disability rates at age 60 of the generation 1955 to the generation 1958.

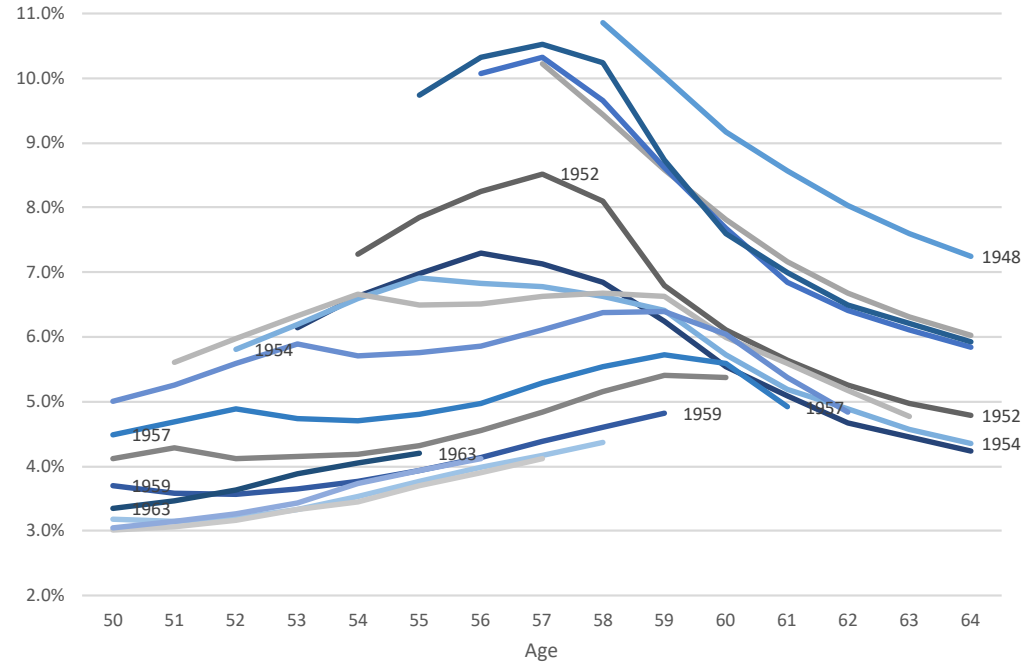
84. These generational changes are more pronounced for women (Figure 24). The age profile of full disability for younger generations has become flatter. The peak age has also been moving right, as the statutory retirement age and the number of children have decreased. Overall, full disability rates at all ages have become lower and smoother. Therefore, a smaller share of younger generations is expected to be in full disability pensions in the decades to come.

Figure 23. Male full disability rate by age per birth cohort
In percentage of all population by age



Source: Administrative data from the Czech Social Security Administration and population statistics from the Czech Statistical Office.

Figure 24. Women full disability rate by age per birth cohort
In percentage of all population by age.



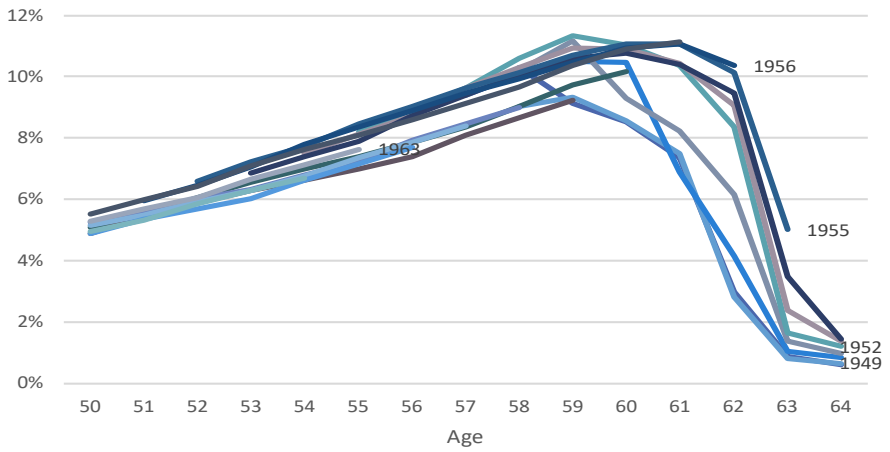
Source: Administrative data from the Czech Social Security Administration and population statistics from the Czech Statistical Office

6.2.2. Partial disability

85. The age profiles of partial disability have been evolving differently. Partial disability rates for men have been increasing regularly from the age of 50 and tend to culminate around the statutory retirement

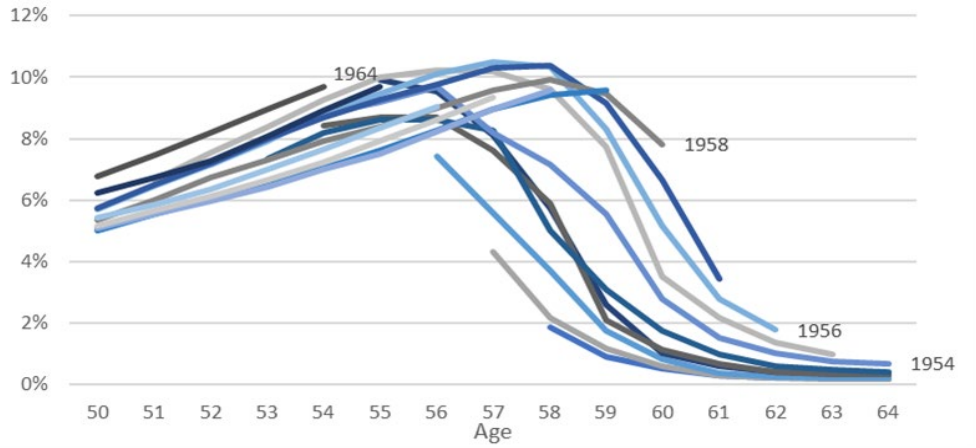
age. Beyond the SRA, partial disability rates plummet to less than 1% at the age of 64, in line with the fact that disability pensions are being swapped into old-age pensions at the SRA. However, rates have increased overall, especially above the age of 60 between the generations born in the early and late 1950s (Figure 25). One can therefore expect that partial disability rates may still increase slightly, reaching their peak about two years before the SRA. Instead of the sharp decline in full disability, women partial disability rates have been increasing for recent generations. In addition, the peak age has been pushed up from the age of 55 for the generation born in 1954 to the age of 58 for the generation born in 1958 (Figure 26).

Figure 25. Age profile of the share of male cohorts in partial disability by generation



Source: Administrative data from the Czech Social Security Administration and population statistics from the Czech Statistical Office.

Figure 26. Age profile of the share of female cohorts in partial invalidity by generation



Source: Administrative data from the Czech Social Security Administration and population statistics from the Czech Statistical Office.

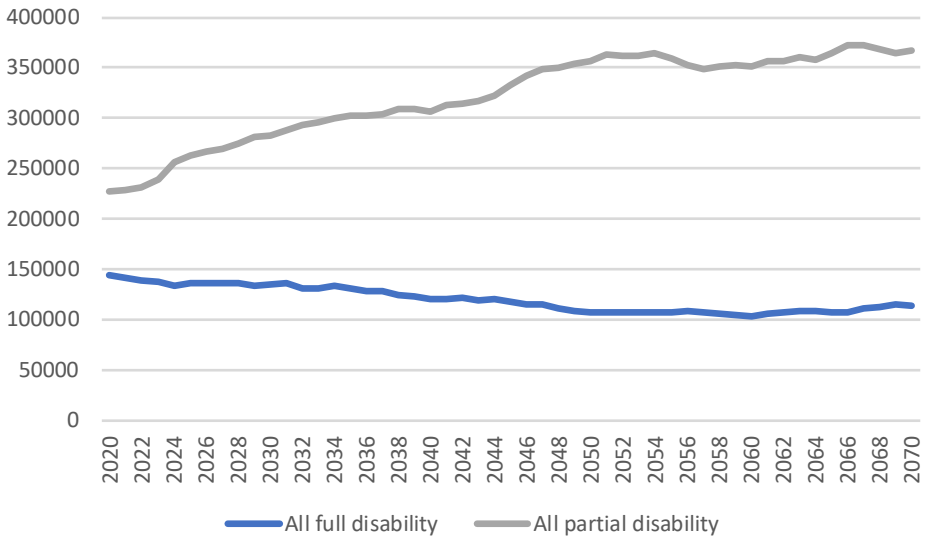
86. The disability rate increases with age to peak at certain age before decreasing. The peak-age of the disability rate is positively correlated to the statutory retirement age, both for gender and degrees of disability. However, the rate of partial disability has responded more positively to the increase in the SRA than the rate of full disability.

87. The cohort model does not assume an explicit connection between the increase in the SRA and the prevalence of disability for the next generations. However, current patterns in the increase of partial disability, especially at later ages, are prolonged using a quadratic trend, assuming that the rates by generation and age are converging to their long-term value by 2025. Women partial disability rates are assumed to converge to what men have been experiencing.

88. In the model, full disability (degree III) and partial disability (combining degree I and degree II) are considered separately to project disability rates by age, education, gender and generation. The main reason for this modelling choice is that disability rates are not available by education level in the Czech Social Security Administration data and we use survey data from SILC, which unfortunately does not differentiate between the different levels of partial disability. Once the partial disability status has been granted to an individual in the pension model, degree I or II, which only affects the level of his/her pension, is drawn randomly with a constant split between the two modalities based on recent trends.

89. The simulations of the cohort model of full and partial disability rates are benchmarked with the historical data (see Annex B). The simulations match overall trends while the levels are less accurate. The cohort model is calibrated with these trends to simulate the number of disability pensioners in the long-run. The number of full-disability pensioners is expected to decline by 25% from 2020 to 2060 (Figure 27). In the meantime, the number of partial disability pensioners will be multiplied by 1.6. This increase will be moderate for men, about 30%, while the number of women on a partial disability pension is likely to double. This rapid increase follows from the prolongation of recent trends, which have seen partial disability rates sharply increase among women.

Figure 27. Projection of the number of disability pensioners



Source: Simulations from the cohort model.

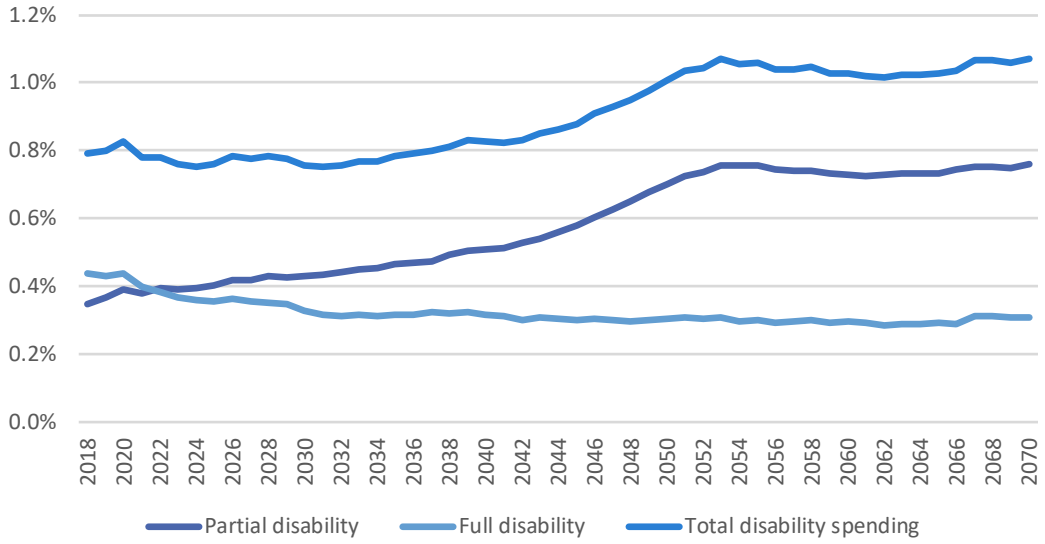
6.2.3. Disability spending

90. The earnings-related component of disability pensions is calculated with different accrual rates for the different degrees of disability. The accrual rate is 0.5% for the first degree disability and 0.75% for the second degree. It is 1.5% for the third degree (full disability). The disability pension formula is then similar to the old-age pension formula. The accrual rate is multiplied with the personal reference wage (assessment base) for every completed year of acquired insurance period. This period makes the difference in case of disability pensions. If a person becomes disabled before he/she reaches the necessary insurance period it is presumed that the disabled person has already reached the retirement age (i.e. the periods between the disability age and the retirement age are counted as validated). If a person becomes disabled before the age of 18, the earnings-related component amounts to 45% of the general assessment base.

91. Prior to 2009, disability pensions were paid beyond the age of 64. In 2010, the system changed and all disability pensions were converted to old-age pensions at statutory retirement age. As the SRA has been increasing, people with disabilities are now staying longer on their disability pensions.

92. Disability spending is projected to increase from 0.8% of GDP in 2019 to 1.1% GDP in 2070 (Figure 28). Spending for full disability pensions will decline, following the number of full-disability pensioners. Partial disability spending is likely to more than double, from 0.35% to 0.8% in 2070. Although the future financial cost of the disability regime per se is likely to remain moderate in proportion of total pension spending, it still may play a critical role as ageing workers, especially in physically challenging occupations, might eventually fall in that category as the statutory requirement age increases. Therefore, it may reduce the impact of the increasing retirement age for a sizeable part of the population.

Figure 28. Projection of disability spending in % of GDP



Source: Simulations from the cohort model.

6.3. Projections of survivor pensions

6.3.1. Marital status and the number of survivor pensions

93. The projections of survivor pensions depend on the evolution of the marital status of pensioners, as official marriage is necessary to be entitled to such a benefit. The share of people either married or widowed in a cohort at the age of 45 has plummeted from 80% in the generation born in 1950 to 57% in the generation born in 1974 among men and from 83% to 61% among women. This downward trend in marriages has not fully affected the pension system yet as among people aged 65, the share of those either married or widowed still remained around 76% in 2019. Among the youngest generations, marriage is still declining. The correlation between the marriage rate at a given age in a given year and five or ten years later is high, both for men and women (Table 1).

Table 1. Correlation between the share of people either married or widowed

In a given year and in 5, 10 or 15 years' time for a given cohort, by gender and age.

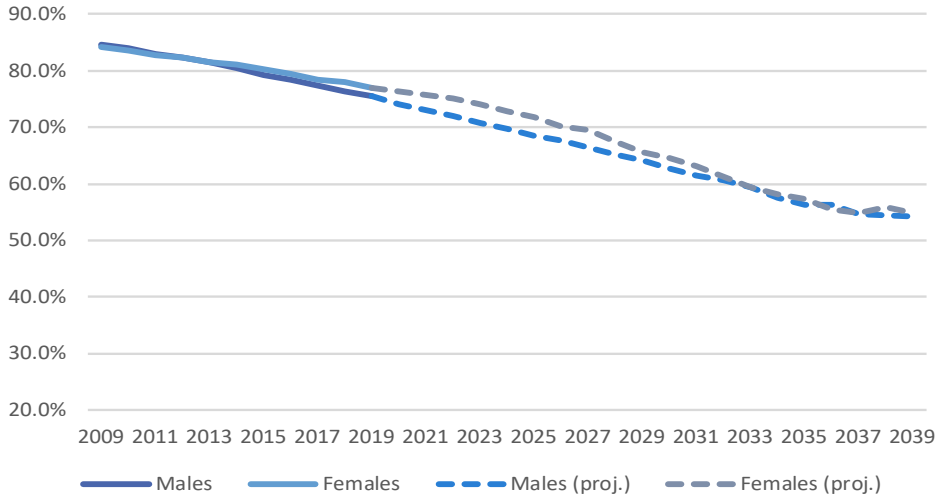
	in 5 years		in 10 years		in 15 years	
Age	Males	Females	Males	Females	Males	Females
36	0.995	0.993	0.991	0.990	0.981	0.982
46	0.996	0.997	0.997	0.996	0.993	0.998
56	0.999	0.999	0.998	0.998	0.995	0.998
66	0.999	0.999	0.998	0.998	0.995	0.998

Source: Computations from Eurostat data.

94. Linear projections of the marriage age profiles are used to project the share of people either married or widowed at the age of 65. The share of people aged 65 and either married or widowed is likely to be around 55% in 2039, both for men and women, compared to 75% to 80% in 2019. This share may stabilise around that level from the early 2040s (Figure 29). This societal evolution is likely to have an important impact on the number of beneficiaries of survivors' pensions in the two decades to come.

Figure 29. Projections of the share of 65-year-old people either married or widowed

In % of the total population of males and females

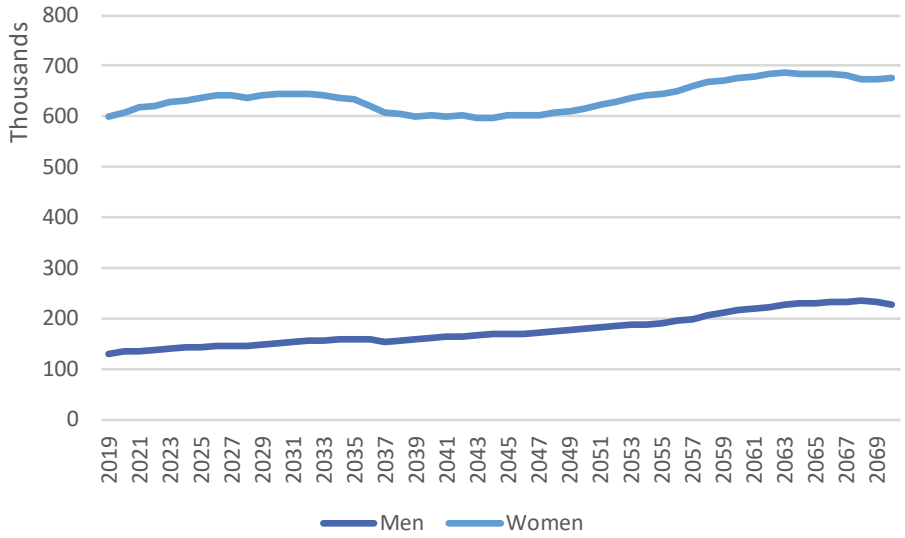


Source: Projections based on population data by age and marital status from Eurostat.

95. The share of widows and widowers in the decades to come by generation can then be projected using projected mortality data and these projections of marriage rates. Thanks to life expectancy gains, the share of widows and widowers has been declining in the past. As life expectancy gains are likely to continue according to the Czech Statistical Office's demographic projections, the share of people in a generation who are widows or widowers at a given age, is likely to drop in the decades to come.

96. Although the share of widowed people at a given age will fall among younger generations, the projected number of survivor pensioners is still expected to rise regularly by about 24% in 2070 (Figure 30). This increase is related to life expectancy gains, especially among men, and the fact that the overall elderly population will grow at a rapid pace in the decade to come due to stronger cohorts born from the 1970s.

Figure 30. Projection of the number of survivor pensioners



Source: Simulations from the cohort model.

6.3.2. Survivor pension spending

97. The model does not model explicitly orphans pensions, as this would require increasing the scope of the simulation significantly, while both the weight of that particular regime and the impact of demographic changes on it are very limited. Orphans' pensions are therefore simply modelled as a constant fraction of widows and widowers' pensions.

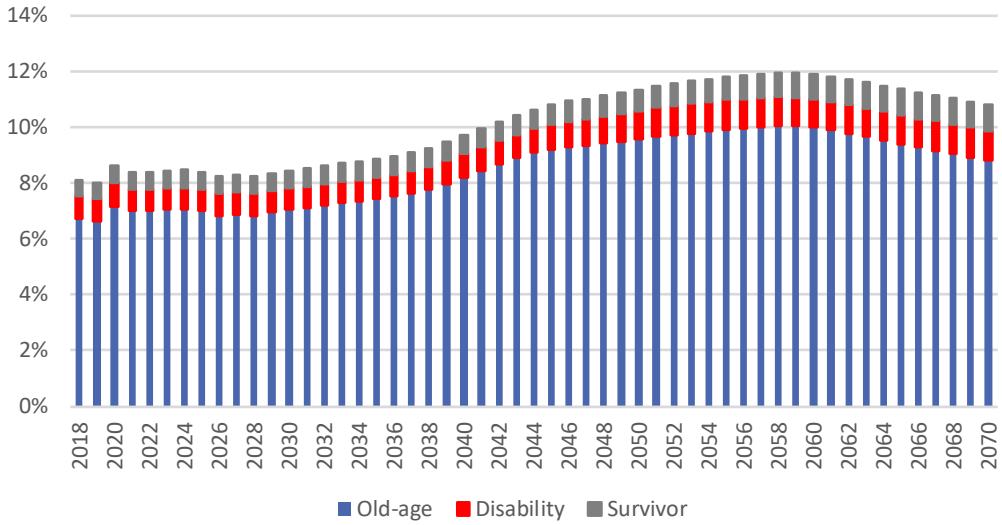
98. The survivor pension rate is 50% of the pension of the deceased person. However, there are restrictions in cumulating a survivor pension and own pension. At the aggregate level, the ratio between the average survivor pension and the average pension is 0.3. Total spending for survivor pensions is predicted to grow from 0.57% of GDP in the latest year to 0.9% of GDP in the 2060s (Figure 31).

7. Financial projections for the pension system

7.1. Spending and revenues of the pension system

99. Pension spending is projected to fluctuate around 8.4% of GDP until 2030. It will then increase progressively to peak at 11.9% of GDP in 2059 and then decline slightly until 2070 (Figure 31). The increase in the retirement age, which will reach 65 years in 2030, is holding back pension spending. After 2030, the increase in pension spending follows the increase in the size of the elderly population.

Figure 31. Projections of pension spending by schemes in % of GDP

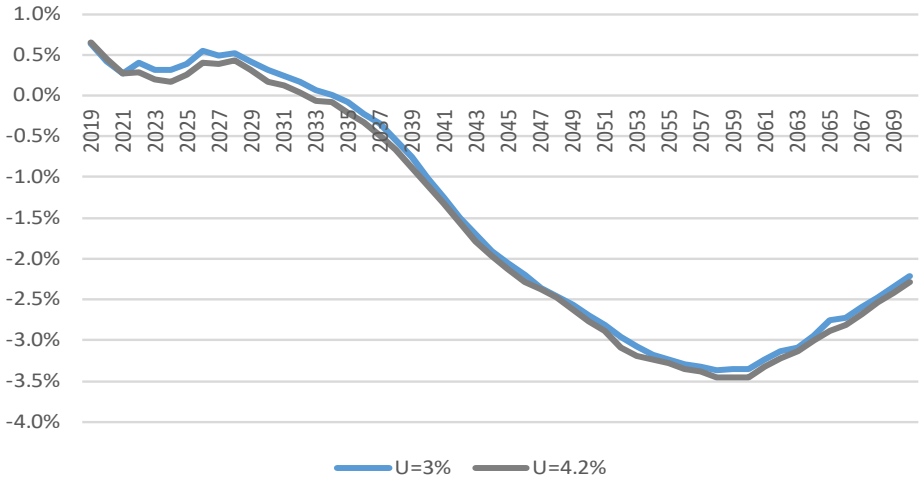


Note: The figure represents the pension spending by type put on top of each other so that the top of the bar of the last category (survivor) indicates the level of total spending.
Source: Simulations from the cohort model.

100. As the pension system is financed by contributions on labour earnings, the projection of revenues follows from assumptions on the unemployment rate, the labour force and the share of self-employed workers. In the baseline scenario (long run unemployment rate at 3%), a small surplus is projected until 2030 as the number of retirees is expected to stagnate (Figure 32). The deficit will peak by the end of the 2050s before declining. Changing the long-term unemployment rate from 3% to 4.2% does not modify much the balance of the system (Figure 32).

Figure 32. Projected balance of the pension system

With long run unemployment rate at 3% and 4.2%.



Source: Simulations from the cohort model.

7.2. Comparison with EU projections

101. Comparing official EU/Ministry of Finance projections to the cohort model shows a similar dynamic of pension spending between now and 2070 (see Table 2 and Table 3). In both projections, pension spending in terms of GDP ratios are projected to be stable over the next 10 years, before increasing.

Pension spending increases by 3.5 percentage points of GDP by 2059, the peak year in EU projections and by 3.3 percentage points in the cohort model. However, in the cohort model, the impact of the COVID-19 crisis on GDP in the short run is taken into account, which increases the pension to GDP ratios in the first periods of the projections. After 2060, pension spending is projected to decrease as big cohorts born in the 1970s leave the pension system and, to a lower extent, as the average validated contribution period declines.

Table 2. EU projections of pension expenditure
Percentage of GDP

	2016	2020	2030	2040	2050	2060	2070	Peak year
Total public pensions	8.2	8.1	8.2	9.2	10.8	11.6	10.9	2059
of which								
old-age pensions	6.8	6.7	6.8	7.7	9.4	10.2	9.5	2059
disability pensions	0.9	0.8	0.8	0.8	0.8	0.7	0.8	2016
survivor pensions	0.5	0.6	0.6	0.7	0.7	0.7	0.7	2062
linked to life expectancy	8.2	8.1	8.0	8.5	9.7	10.2	9.3	2059

Note: The baseline scenario is computed with the fixed ceiling on statutory retirement age. The last row represents a scenario linking the statutory retirement age to the life expectancy.
Source: European Commission (2018).

Table 3. Pension spending simulated by the cohort model
Percentage of GDP

	2020	2030	2040	2050	2060	2070	Peak year
Total public pensions	8.6	8.4	9.6	11.3	11.9	10.8	2059
of which							
old-age pensions	7.2	7.0	8.2	9.6	10.0	8.8	2059
disability pensions	0.8	0.8	0.8	1.0	1.0	1.1	2070
survivor pensions	0.6	0.6	0.6	0.7	0.9	0.9	2059

Source: Baseline simulation of the cohort model.

8. Quantification of policy reforms

102. Different policy reform options exist to cope with the impact of ageing on public finances. In particular, increasing the retirement age reduces the number of age cohorts in retirement while augmenting the labour force. Indexing pensions in payment on price inflation would reduce spending while preserving the purchasing power of retirees, but it would raise the income gap between retirees and workers. Increasing contribution rates and taxes make workers carry a large burden of financing the impact of ageing. Specific changes to the pension rules can also be made that would affect the level of the first payment by changing for instance the assessment base, the uprating of past wages or the accrual rate (see chapters 1 and 3, OECD, 2020).

103. The choice between these options is a policy decision that ultimately reflects the degree of fairness and redistribution desired. The simulation exercise focuses on the main parameters to give an overview of the different routes that could be taken to close the financing gap driven by ageing. Due to the planned increase in retirement age until 2030, pension spending will remain stable in the next decade and will start to increase slowly before accelerating from 2040. This dynamic of pension spending allows to introduce reforms that will progressively affect spending and/or revenues.

8.1. Increasing the retirement age

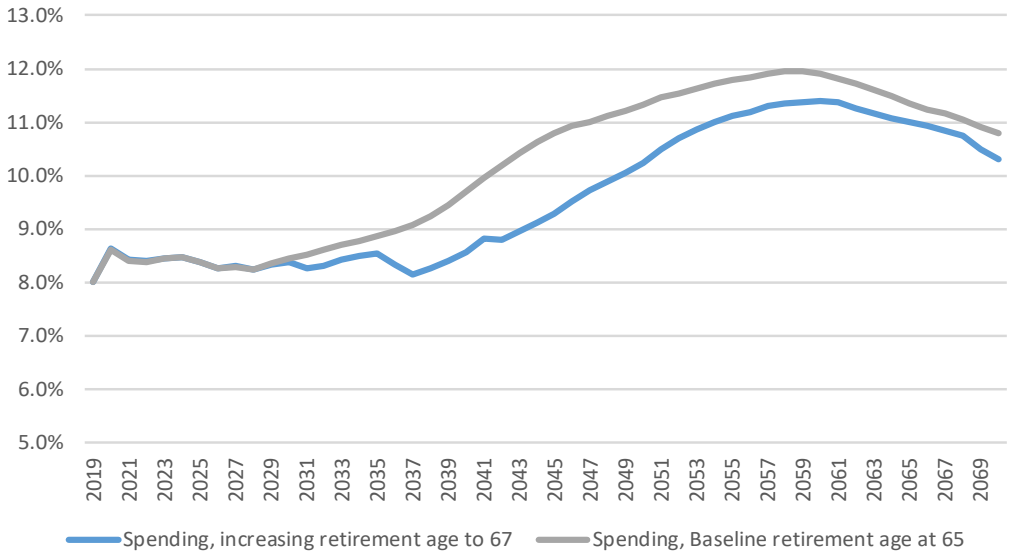
104. The current planned increase in the statutory retirement age to 65 in 2030 is prolonged to 67 after 2030. The simulation takes into account the impact of the increase in the retirement age on the active

population and on GDP. However, no change in labour productivity is introduced. Also, participation rates are just shifted along with the increase in the statutory retirement age.

105. In the increasing retirement age scenario, the projected spending would be stable until 2040 before rising and reaching a peak in the late 2050s, albeit at a lower level compared to the baseline: in 2050, pension spending would be lower by 1.1 percentage points of GDP compared to the baseline. In 2059, the peak year of pension spending, the reform would lower spending by 0.6 percentage point (Figure 33). The impact of increasing the retirement age on spending is higher between 2035 and 2060, it diminishes over time as large cohorts of retirees born in the 1970s leave the pension system. Also, with the increase of the retirement age, revenues collected by the pension system rise by around 2.5%.

Figure 33. Projection of pension spending with increasing retirement age to 67

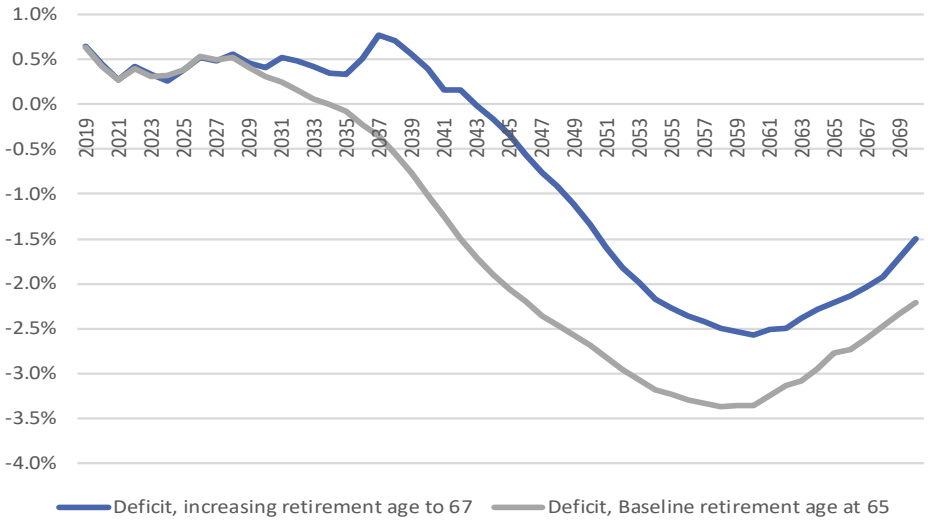
Progressive increase in retirement age compared to current legislation, in % of GDP.



Source: Simulations from the cohort model.

106. Increasing the retirement age reduces the deficit of the pension system (Figure 34). The reduction of the deficit is highest between 2040 and 2050 where it reaches between 1.4 and 1.7 percentage points of GDP. However, increasing the retirement age to 67 will not be enough to close the financing gap as the deficit will still be around 2.5% of GDP in 2060. Additional reforms will be needed to close the financing gap.

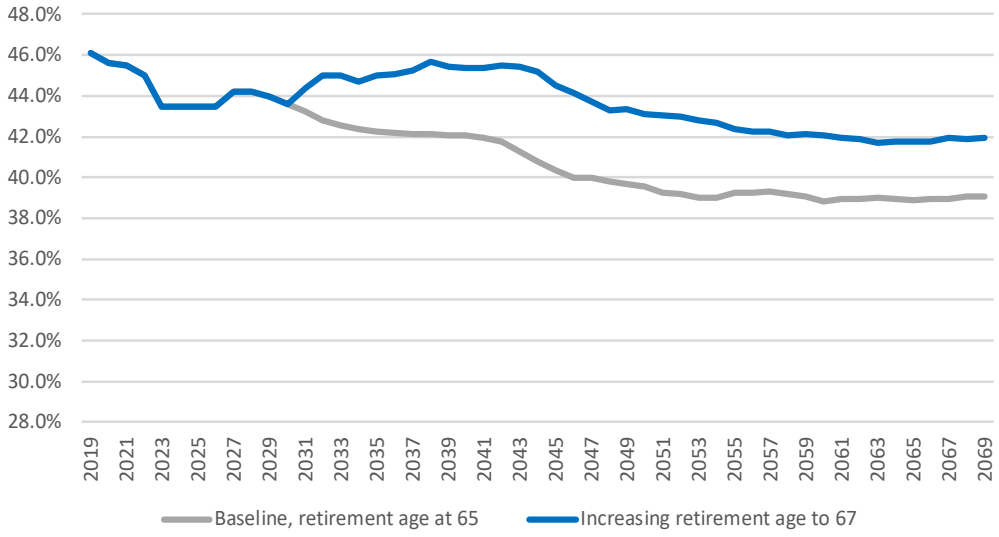
Figure 34. Balance of the pension system in the increasing retirement age scenario
Balance with retirement age at 67 and 65 (baseline), in % of GDP.



Source: Simulations from the cohort model.

107. These projections include the increase in pension levels induced by higher retirement ages. Assuming that employment and participation rates are translated fully into higher ages, individuals will on average accrue more contribution periods and pension rights. The pension replacement rate defined as the ratio of newly granted pensions on the average wage would increase on average by 3 percentage points over the projection period (Figure 35). Therefore, increasing the retirement age improves the adequacy of the pension system.

Figure 35. The pension replacement rate increases with retiring later
Ratio of the newly granted pensions to the average wage.



Source: Simulations from the cohort model.

8.2. Indexing pensions with inflation

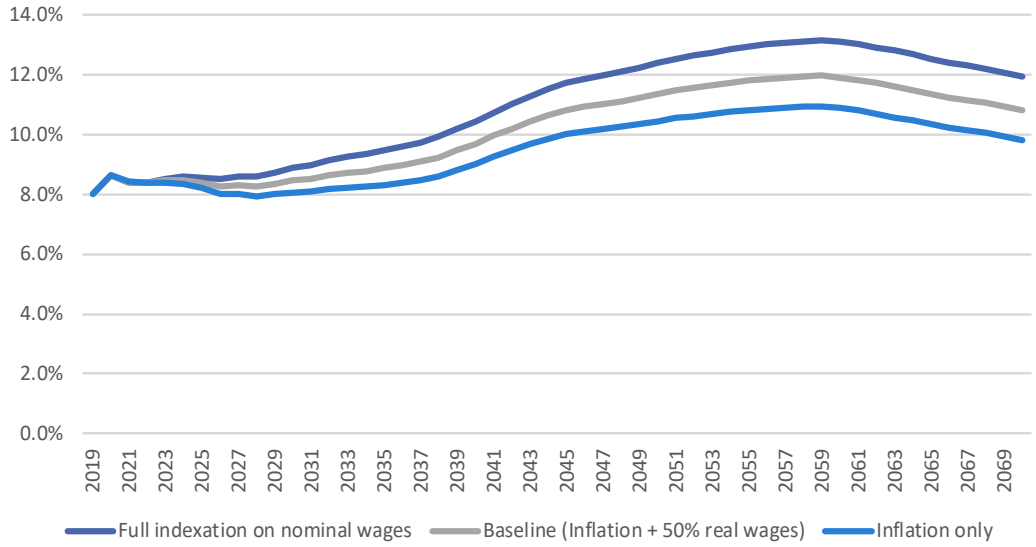
108. Another reform option is to change the indexation of pensions. In the current legal framework, pensions are indexed with inflation and half of real-wage growth. An alternative scenario would consist in indexing pensions with inflation, preserving only their purchasing power. Overall pension spending is

significantly lower when the real-wage indexation component is removed. At the peak in 2059, pension spending would be 0.9 percentage point of GDP lower than in the baseline[10] (Figure 36). This impact is comparable to that from increasing the retirement age.

109. However, in recent years, pension indexation has been more generous than the indexation rule. Guillemette's (2019) projections based on estimates of past pension indexation behaviour found that pension spending would reach 12.7% of GDP in 2060 in the Czech Republic. When assuming that old-age pensions are fully indexed to nominal wages in the future, pension spending would reach 13.1% of GDP in 2060 in the cohort model. These simulations underline that indexation is an important tool for pension finances.

Figure 36. Indexation of pensions with inflation will reduce expenditures

Pension spending with indexation of pensions with nominal wage, inflation plus 50% real wage growth and inflation, in percentage of GDP



Source: Simulations from the cohort model.

8.3. Increasing the fiscal resources for the pension system

110. The macroeconomic framework allows simulating increases in taxes on labour, corporate income and value added tax (VAT). One can compare the effectiveness of these policy options by computing the effects of raising each tax separately so that additional revenues collected (ex ante) would represent 1% of GDP. Tax increases have negative effects on the macroeconomic aggregates, which tend to decrease all types of public revenues (Table 4). There are negative effects of increasing any tax. For a tax increase targeting 1% of GDP of additional revenues ex-ante, the net additional revenue is estimated to be only between 0.4% to 0.5% of GDP ex-post, while wages and employment both decline by 2%, which represents a 4% drop in labour earnings as a whole.

111. Increasing the value-added tax (VAT) appears to be the least efficient scenario, as a large share of household income, and thus consumption depends on labour earnings. At the same time, VAT is levied

[10] In the variants, the macroeconomic framework remains the same, which means that the feed-back effect of lower pensions on domestic consumption in the long-run is neglected. This assumption is motivated by the fact that the marginal propensity of consumption tends to decline with age.

on investment goods, and thus, a higher VAT increases the cost of capital, so that it is at the same time depressing supply and demand.

112. Comparable increases of corporate taxes or social contributions are likely to bear the same effect overall on GDP and public revenue collection. However, the negative effect of increasing taxes on corporate earnings on employment is lower than the effect of increasing social contributions.

113. Because the model functions at the margin, it is linear and one can add the columns of Table 4 to analyse the mix of fiscal measures. For instance, shifting part of social contributions to additional taxes on corporate income or other capital income would allow, for a given level of public revenue, to reduce the pressure on labour tax and thus to boost employment.

Table 4. Long-run impact of tax increases on GDP and tax revenues

Type of tax	Business tax	Social contributions	VAT
Real GDP in percentage of long run level	-1.7	-1.8	-1.9
Employment in percentage	-0.8	-2.0	-1.5
Unemployment rate in percentage	0.6	1.6	1.1
Real wages in percentage	-0.9	-0.5	-0.4
Public revenues in pp. GDP	0.5	0.5	0.4
Taxes on labour in pp. GDP	-0.3	0.7	-0.3
Taxes on capital in pp. GDP	1.0	0.0	0.0
Indirect taxes in pp. GDP	-0.2	-0.2	0.7
Baseline effective tax rate	*5.5*	*28.8*	*13.3*
Effective tax rate increase in pp	*2.2*	*2.5*	*1.2*

Note: The table presents the long-term effects of an increase in three types of taxes so that additional revenues before the economy adjust would represent one GDP point. For the corporate tax, such a policy would imply to increase the effective tax rate by 2.2 percentage points (from 5.5%). The long run GDP level would fall by 1.7% compared to where it would have been without the policy, while employment would decrease by 0.8% compared to the baseline scenario and the unemployment rate would increase by 0.6pp – going from 3% to 3.6%. Real wage growth would decrease by 0.9% from the baseline scenario. After the economy would have adjusted to the new measure, the total public revenues collected would be 0.5 percentage points of GDP higher compared to what would have occurred in the absence of tax increase.
Source: Simulations from the macroeconomic framework.

8.4. Increasing social contributions of self-employed workers

114. A macroeconomic assessment of increasing the social contributions of the self-employed indicates that it is likely to reduce employment and have negative effects on GDP as well (Table 5). Increasing social contributions for the self-employed by expanding their tax base would have, however, less damaging effects than raising the social contribution rates for all workers. However, a thorough assessment of the effects of changing the taxation of the self-employed requires individual data, and is beyond the scope of this study. For a given gross labour income, the self-employed are indeed less taxed, as they can deduct a large share of their income as costs from their tax base. As a result, their effective social contribution rate is much lower than that of employees.

8.5. Relaxing the mandatory contribution period

115. The mandatory 35 years of validated contribution period or 30 years of contributed period to be eligible for a pension will start to be binding in the late 2050s. The simulations show that on average around 10% of a cohort could reach the statutory retirement age without fulfilling the contribution period requirement (Figure 13). Though this is a projection and is subject to variations of career paths depending on the future of the labour market, it gives an indication on the degree of strictness of the contribution period requirement. An alternative is to allow the possibility to retire at the statutory retirement age but with a pension proportionated to the validated contribution period. Relaxing the mandatory contribution period,

once the statutory retirement age is set at 65, would increase spending by slightly less than 0.2 percentage point of GDP while revenues will only be affected marginally (Table 5).

Table 5. The impacts of the different policy options

Policy options	Deficit at peak year (in pp)	Impact on employment (in %)	Impact on GDP (in %)	Other effects
Increase SRA until 67	-0.7	+3	+3	Uncertainty on productivity effect and participation likely lower than projected
Old pensions indexed with inflation	-0.8	Limited	Limited	Impact on GDP likely negative but precise estimate would require much more complicated macroeconomic modelling with heterogeneous agents.
Increase effective capital tax rate by 2.2 pp.	-0.5	-0.8	-1.7	Foreign capital losses are fully taken account, but are likely to be lower in practice, as transfer of production units abroad take time.
Increase self-employed effective contribution rate by 5 points	-0.2	-0.7	-0.8	Increase in fairness, increased tax evasion of self-employed
Relaxing mandatory contribution period	+0.2	Marginal	Marginal	Bridge coverage of "unlucky" workers

Source: Simulations from the cohort model and the macroeconomic framework.

References

European Commission (2018), The 2018 Ageing Report: Economic & Budgetary Projections for the 28 EU Member States (2016–2070), Publications Office of the European Union, Luxembourg.

Fall, F. (2014), "Comparing the Robustness of PAYG Pension Schemes", *OECD Economics Department Working Papers*, No. 1134, OECD Publishing, Paris, HYPERLINK "https://doi.org/10.1787/5jz158w3ghmx-en" https://doi.org/10.1787/5jz158w3ghmx-en .

Guillemette, Y. (2019), "Recent improvements to the public finance block of the OECD's long-term global model", *OECD Economics Department Working Papers*, No. 1581, OECD Publishing, Paris, https://dx.doi.org/10.1787/4f07fb8d-en.

Ministry of Finance (2020), *Macroeconomic Forecast – April 2020*, HYPERLINK "https://www.mfcr.cz/en/statistics/macroeconomic-forecast/2020/macroeconomic-forecast-april-2020-38096" https://www.mfcr.cz/en/statistics/macroeconomic-forecast/2020/macroeconomic-forecast-april-2020-38096 .

Ministry of Finance (2017), Pension projections of the Czech Republic. Country fiche for the AWG Ageing Report 2018, Ministry of Finance of the Czech Republic.

OECD (2020), OECD Reviews of Pension Systems: Czech Republic, OECD Reviews of Pension Systems, OECD Publishing, Paris, https://doi.org/10.1787/e6387738-en.

Annex A. Macroeconomic framework

The framework considers a one-sector small open economy. The model is log-linear around the steady state. The macroeconomic equilibrium is summarised by three main variables and three principal equations. The main price variable is the inverse of the real exchange rate, which is defined in logarithm form as follows, where *e* is the nominal exchange rate in log, *p* the production price and p^* the foreign price.

$$q = e + p^* - p \quad \text{(E1)}$$

The GDP is denoted *y* and the nominal interest rate is denoted *i*. The three principal relationships are:

i. The supply curve, where the GDP decreases with the real exchange rate, as all factor costs: inputs, capital and wages tend to increase with the inverse of the real exchange rate, and increases with the nominal interest rate, which is a component of the cost of capital.

ii. The demand curve is increasing with the real exchange rate as the prices of consumption, investment, exports and public spending all increases with the inverse of the real exchange rate; the demand curve is also increasing with the nominal interest rate, which pushes up the investment cost.

iii. The balance of payment where the difference between exports and imports is compensated by the net flow of foreign capital. Net exports are increasing with the real exchange rate and decreasing with the nominal interest rate, which penalises imports of capital. The flow of foreign capital is an increasing function of the differential between the nominal interest rate and the foreign interest rate, once taken into account the expected trend in the nominal exchange rate.

The supply curve

The production frontier allows writing a relationship between the labour cost *w* and the capital cost *r*, where α is the capital share and μ is the mark-up.

$$\alpha(r + \dot{\tau_K}) + (1 - \alpha)w = -\mu \quad \text{(E2)}$$

The production function allows writing the GDP as a linear function of total employment ant the capital intensity, which can further be related to the cost of capital using the properties of the Cobb-Douglas function.

$$y = a + l + \frac{\alpha}{1-\alpha}(k - y) = a + l - \frac{\alpha}{1-\alpha}(r + \dot{\tau_K}) \quad \text{(E3)}$$

The supply of work is derived from the wage bargaining equation, which relates the net wage to the reservation wage ϖ, the employment rate (Phillips curve), where n^0 is the working-age population, ϕ is the Phillips coefficient and γ measures the flexion of the labour force in response to the employment rate $(l - n^0)$.

$$w - \dot{\tau_L} = q_c + \varpi + \phi\gamma(l - n^0) \quad \text{(E4)}$$

Thanks to consumer optimisation between domestic and foreign imported products, the consumption price q_c can be related to the real exchange rate and the VAT rate $\dot{\tau_C}$, where α_C is the share of imported consumption in value at the steady state:

$$q_c = \alpha_C q + \dot{\tau_C} \quad \text{(E5)}$$

Plugging the wage bargaining equation (E4) into the price frontier (E2), after having replaced the consumption price with (E5) allows deducing the labour supply as a function of the real exchange rate, the changes in taxes, the cost of capital and the mark-up:

$$l^s = n^0 - \frac{1}{\gamma\phi}\left(\alpha_C q + \dot{\tau_L} + \dot{\tau_C} + \frac{\alpha}{1-\alpha}(\dot{r} + \dot{\tau_K}) + \frac{1}{1-\alpha}\mu + \varpi\right) \quad \text{(E6)}$$

The cost of capital can be expressed as a function of the nominal exchange rate and the nominal interest rate *i,* as it is a linear function of the cost of investment, and of the expected inflation π^{+1}.

$$r = \alpha_i q + \dot{\tau_C} + i - \pi^{+1} \quad \text{(E7)}$$

As this is a long-term framework, expected inflation equals the target inflation rate, and one has $\pi^{+1} = \pi$.

Finally, by plugging (E7) and (E6) into the production function (E3) one can obtain the supply curve (E8). This is indeed an increasing function of the price and a decreasing function of the nominal interest rate, the taxes, and the mark-up:

$$y = a + n^0 - \frac{1}{\gamma\phi}\left(\alpha_C q + \dot{\tau_L} + \dot{\tau_C} + \frac{1}{1-\alpha}\mu + \varpi\right) - \frac{\alpha}{1-\alpha}\left(1 + \frac{1}{\gamma\phi}\right)(\alpha_i q + \dot{\tau_C} + i - \pi + \dot{\tau_K}) \text{ (E8)}$$

The demand curve

The demand curve derives from the balance of the product market. The production corresponds to the sum of private consumption, investment, intermediate domestic inputs, public consumption and exports. Each of this aggregate depends on the aggregate price, through an optimisation process between domestic products and imports. The equilibrium is log-linearised around the steady state and one denotes θ_j the respective shares in the production of the aggregate *j.*

$$(1 + \theta_z)y = \theta_c c^d + \theta_i inv^d + \theta_z z^d + \theta_x x + (1 - \theta_c - \theta_i - \theta_x - \theta_z)g \text{ (E9)}$$

Exports are linked to foreign demand x^* and price competitiveness:

$$x = x^* + \eta_X q \quad \text{(E10)}$$

Domestic intermediate inputs also depend on the GDP and the price competitiveness η_Z and the share of imported inputs in value at the steady state α_z:

$$z^d = y + \alpha_z \eta_Z q \quad \text{(E11)}$$

Investment is derived from the optimisation of the capital stock:

$$inv^d = y - (r + \dot{\tau_K}) + \eta_i \alpha_i q - \dot{\tau_C} \quad (12)$$

Domestic consumption depends as well from aggregate consumption *c*:

$$c^d = c + \eta_c \alpha_c q \quad \text{(E13)}$$

The model is closed by assuming that consumers are Keynesian: they consume a constant fraction of their disposable income. This form describes well the features of the Czech economy where most of the disposable income comes from labour earnings, as a large share of the capital is foreign-owned while the market of the consumption credit remains very limited and most households are liquidity constrained due to high levels of redistribution. Denoting $\dot{\tau_Y}$ the change in the tax on income, this leads to:

$$c = y - \dot{\tau_Y} - \alpha_c q - \dot{\tau_C} \quad \text{(E14)}$$

This allows expressing the domestic consumption as:

$$c^d = y - \dot{\tau_Y} - \dot{\tau_C} - (1 - \eta_c)\alpha_c q \quad \text{(E15)}$$

Combining equations (E10) to (E15) with the equilibrium (E9) leads to the demand curve.

The balance of payment

The trade balance is simply written as nominal exports minus nominal imports, where imports follow from the price optimisation of consumers, producers and investors.

$$m_z = z^d + \eta_Z q = y - (1 - \alpha_z)\eta_Z q \quad \text{E(16)}$$

Imported investments depend of the VAT and the capital cost:

$$m_i = inv^d + \eta_i q = y - (r + \dot{\tau_K}) - \dot{\tau_C} - (1 - \alpha_i)\eta_i q \qquad \text{E(17)}$$

Imported consumption is derived:

$$m_c = c - \eta_c(q + \dot{\tau_C} - q_c) = y - \dot{\tau_Y} - \dot{\tau_C} - (\eta_c(1 - \alpha_c) + \alpha_c)q \qquad \text{E(18)}$$

The trade balance is therefore a positive function of the foreign demand, a positive function of the real exchange rate and a negative function of the nominal interest rate.

$$BC = \theta_x(x^* + \eta_X q) - \theta_z m^z - \theta_c m^c - \theta_i m^i \qquad \text{E(19)}$$

The capital account is derived from the maximization of the investor utility, which weighs expected returns and the variance of her portfolio. One has:

$$BK = y + \rho(i - i^* + \Delta e) \qquad \text{(E20)}$$

The sum of the trade balance and the capital account is always zero:

$$BC(y, q, \tau_j, i) + BK(y, q, \tau_j, i) = 0 \qquad \text{(E21)}$$

By solving simultaneously the linear system of (E8), (E9) and (E21) one can determine the macroeconomic equilibrium.

Extension of the macroeconomic model to take into account self-employment

Let us denote $\tau_s$and $\tau_e$the respective effective tax rate of the self-employed and employees. The wage bargaining process on the labour market for employees can be summarised by the following equation in logarithm, where the net wage, corresponding to the gross wage w_e minus social contributions τ_e equals the consumption price $q_c$and the employment gap $(l - n)$. One denotes $\lambda_s = \lambda$ the ratio of average self-employed productivity to average labour productivity and $\lambda_e = 0$, and μ the ratio of the self-employed in total employment:

$$w_e - \frac{d\tau_e}{1-\tau_e} = q_c + \phi(\mu l_s + (1 - \mu)l_e - n) \text{ (E22)}$$

The production function is modelled as:

$$Y = \left(\kappa L_s^{1-1/\sigma} + (1 - \kappa)L_e^{1-1/\sigma}\right)^{\sigma/\sigma-1} \text{ (E23)}$$

As a consequence of labour optimisation of the producers, one has:

$$w_e - w_s = -\frac{1}{\sigma}(l_e - l_s) \text{ (E24)}$$

Workers choose to work as self-employed by considering their net income. This leads to:

$$w_e - w_s - \frac{d\tau_e}{1-\tau_e} + \frac{d\tau_s}{1-\tau_s} = -\frac{1}{\eta}(l_e - l_s) \text{ (E25)}$$

These two relations taken together allow expressing the relative weight of employees and self-employed workers as a function of the tax wedges:

$$\frac{d\tau_e}{1-\tau_e} - \frac{d\tau_s}{1-\tau_s} = \left(\frac{1}{\sigma} - \frac{1}{\eta}\right)(l_e - l_s) \text{ (E26)}$$

From this, one can deduce the expression of the overall labour cost:

$$w = w_e + \left(\mu - \varpi\left(1 + \frac{1}{\sigma}\right)\right)\left(\frac{1}{\frac{1}{\eta} - \frac{1}{\sigma}}\right)\left(\frac{d\tau_e}{1-\tau_e} - \frac{d\tau_s}{1-\tau_s}\right) \text{ (E27)}$$

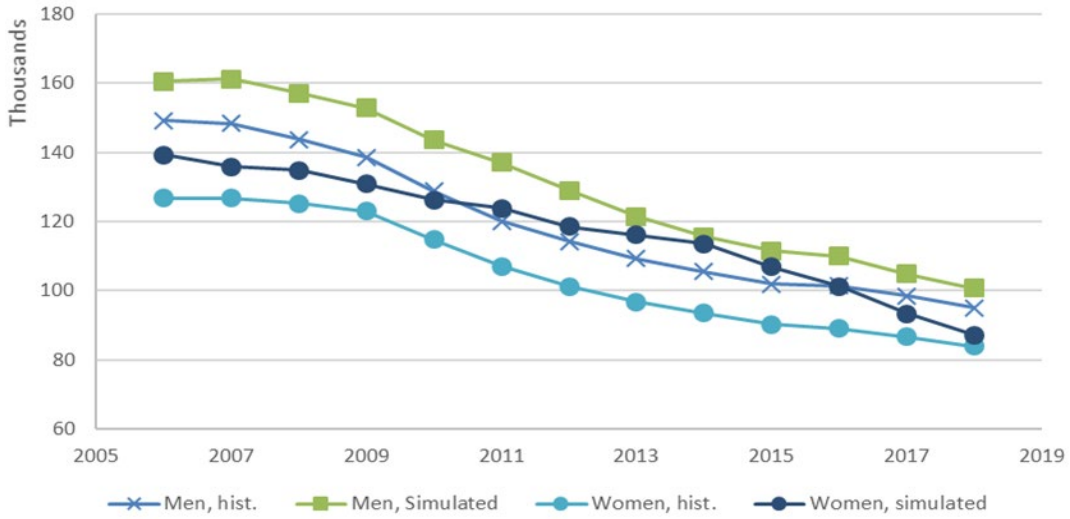
As the labour cost is defined by the interest rate on the price frontier, one can deduce from this equation the gross wage of employees and, using the wage bargaining equation, total employment. From (eq. 12) one can compute both the number of employees and self-employed workers and from (E 6) the GDP.

Annex B. Comparing recent trends and simulations of disability pensioners

116. The cohort model simulates the evolution of the number of disability pensioners below age 65. Although trends are consistent, there are differences in levels (Figure A B.1. and Figure A B.2.). A partial explanation is that the cohort model does not allow people retiring within a year, which tends to increase the retirement rate at a given age. The remaining differences are explained by the difficulty to reproduce disability rates in the years preceding retirement, especially for women in full disability. Disability rates are difficult to estimate, as pensioners leaving the regime by switching to the old-age pension are partially offset by late entries in the disability regime just before retirement age.

Figure A B.1. Comparing recent trends and simulation of full disability pensioners

Number of people in full-disability pensions, thousands.

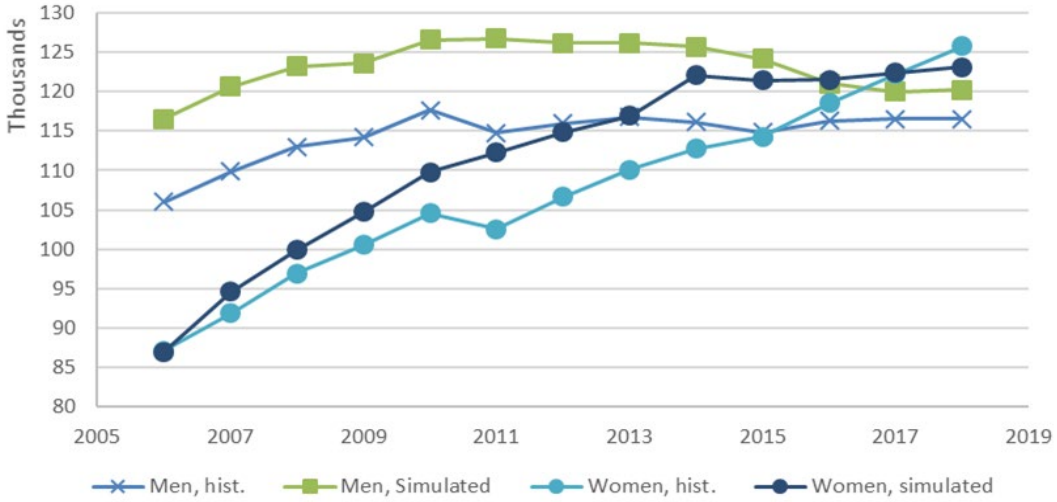


Note: Calculations averaged from four simulations of the cohort model and Czech Social Security Administration data. The historical figures presented in the figure do not include disability beneficiaries older than 64, who were not switched to old-age pension prior to 2010. This allows comparing historical figures and simulations on a stable perimeter.

Source: Calculations from simulations of the cohort model and Czech Social Security Administration data.

Figure A B.2. Recent trends and simulation of partial disability pensioners

Number of people in partial disability pensions, thousands.



Note: Calculations averaged from four simulations of the cohort model and Social Security data. The historical figures presented in the figure do not include disability beneficiaries older than 64, which were not switched to old-age pension prior to 2010. This allows comparing historical figures and simulation on a stable perimeter.

Source: Calculations from simulations of the cohort model and Social Security data.