Ministry of Finance
Czech Republic

The Methodology of Pension Projections

Jindřich Marval, Zbyněk Štork

Methodological Compendium

The Methodology of Pension Projections

Jindřich Marval, Zbyněk Štork

Methodological Compendium

Ministry of Finance of the Czech Republic
Letenská 15, 118 10 Praha 1

First edition, Praha 2018
E-mail: Jindrich.Marval@mfcr.cz, Zbynek.Stork@mfcr.cz

ISBN 978-80-7586-021-7 (on-line)

Free distribution

Electronic archive:
http://www.mfcr.cz/methodology

The Methodology of Pension Projections

Jindřich Marval, Zbyněk Štork

Methodological Compendium

Contents

The Methodological Compendium presents the methodological approaches of the Ministry of Finance of the Czech Republic in the areas of macroeconomic and fiscal analyses, forecasts and projections.

We will gladly welcome relevant comments or suggestions to improve the publication. Please send any comments to the author of the publication.

Introduction and Summary

Long-term pension projections are an important part of the long-term sustainability analysis conducted by Ministry of Finance, European Commission, International Monetary Fund, Organisation for Economic Cooperation and Development or for example rating agencies. Unlike forecasts, projections depict the trends on a "what-if" principle. Thus, the interpretation of the results is less straightforward and the length of horizon might pose some questions about usefulness of such exercises. Their important contribution is in indicating future pressures on public finances if the reality goes like the assumptions, weighing less on exact value.

Necessarily, projections start from creating a demographic scenario, which serves as a main input for long term projections. All scenarios of future development of population show that the Czech Republic, like many other countries, will face the problem of ageing population. In other words, it means that in following decades we will witness a relative increase in the share of elderly people on younger, economically productive population. The trend in demography is quite predetermined even in the long run as newly born generations will get retired around 65 years or later. Applying calculated fertility and mortality rates, one can set a trajectory of future population development. What is completely unknown is migration that must be projected virtually entirely based on some assumptions. Based on population development, assumptions about macroeconomic scenario can be created. On top of the demographic consequences for labour input, the current state of the economy and possible way forward due to convergence of the Czech economy that is constantly underway is taken into account.

This also answers the question of the projection horizon. If the population projection is reliable at least in the terms of its trend, 50 years or more ahead projection can provide a good deal of information. The pension system is itself a long-run scheme. One is obliged to pay contributions for at least 35 years (or 30 years respectively) to receive the pension benefit. In other words, the contributions to the scheme are the government's liability to pay pension benefits in the future. Being aware of the future risk is highly needed for the government.

Beside the baseline projection the sensitivity analysis is necessary. As the long-run assumptions are always highly uncertain, the sensitivity analysis may have two main goals. The first one is to tackle the uncertainty itself. The second goal may be the look at the possible ways forward. The examples for the latter are clear: different net migration and thus affecting the labour force, linking retirement age to life expectancy, higher fertility rate, different indexation formula etc. All these results should support the government's efforts to explain the possible future risks to general public.

Projections of future pension expenditure pressures are important part of broader aspect of sustainability of public finances. Changes in population structure also affect other social security systems, namely health care, long-term care and education. How to project these expenditure types are explained in a separate compendium (Bělohradský, 2018). All these types of expenditure together represent so called age-related expenditures and are inputs for sustainability analysis.

The Ministry of Finance has been involved in the pension projections mainly via the Economic Policy Committee's Ageing Working Group since 2004. The semi-aggregated model is used to fit the assumptions provided by Eurostat (demography) and European Commission (macroeconomic development). The model consists of three blocks, the first dealing with the number of pensions, the second with newly granted pension benefits and finally the third one computing the average pension and total pension expenditure. The pension projections of the Ministry of Finance deal with the pay-as-you-go scheme excluding the schemes for armed forces (amounting approx. to 0.2% of GDP). There are all types of pensions included, i.e. the old-age, disability and survivors pension benefits. The results are regularly peer reviewed within the Ageing Working Group and published in Ageing Reports and in the publications prepared of the Ministry of Finance like Convergence Programme of the Czech Republic and Fiscal Outlook of the Czech Republic.

Long-term projections are also reflected in the European Union's fiscal rules. The medium-term budgetary objective, the crucial part of Stability and Growth Pact's preventive arm, contains part of the future costs of ageing. The governments fulfilling the medium-term budgetary objective are contemporaneously frontloading resources to offset higher pressure on public expenditures that are to come due to ageing. Moreover, the Fiscal Pact conditions, to a certain extent, the magnitude of medium-term budgetary objective with the sustainability risks; the higher the risks, the higher structural balance required.

Thus, the governments and their economic policies are affected nowadays by long-term projections in several aspects. The future risks caused by costs of ageing are visible and the pressure to find the solution is harder. At the same time, lower long-term sustainability of public finances sets larger limits to expenditure policy in present time. Solving the sustainability issue brings more opportunities now and higher confidence for the future.

1 Projection Framework

1.1 Data Used

The model uses data since 2000. Most of them come from the Czech Social Security Administration, which is in charge of collecting social security contributions and disbursing all pension benefits. The model makes use of the information on:

- the number of pensions disaggregated by type of pension, single age and gender,
- the number of new pensions (by type of pension, single age and sex),
- average pension benefit (by type of pension, single age and sex),
- average newly granted pension benefit (by type of pension, single age and sex),
- matrix of the number of new pensions (by type of pension) for a given combination of personal assessment basis and contributory period.

Apart from the above-mentioned data running the model requires a population projection (disaggregated by single age and sex), assumption on the average wage, labour market and macroeconomic scenario. All these data are taken from common projection framework created in cooperation with the Ageing Working Group of the Economic Policy Committee of the European Union.

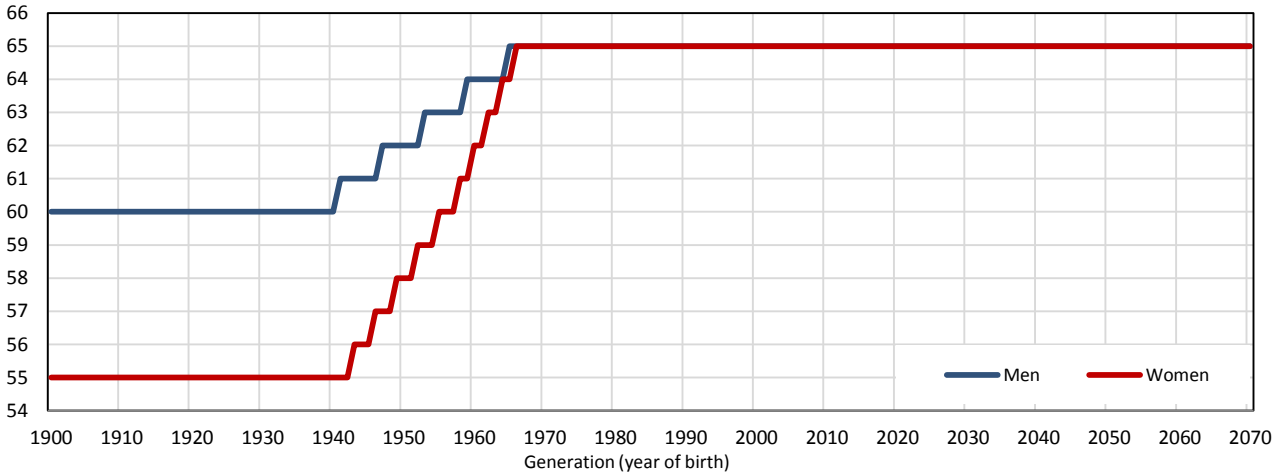
Publicly available data on wage statistics from the Czech Statistical Office are used to calculate the share of pre-retirement wage on average gross wage. The share is then applied to Ageing Working Group's wage assumptions.

1.2 Legal Framework

The model fully applies current legislation. Recently, there has been a crucial legal reform regarding the mechanism for assessing the retirement age. Formerly, there was an automatic rule for unlimited increase in the retirement implicitly coping with the shifts in life expectancy. The 2017 amendment to Act No. 155/1995 Coll. introduced age ceiling of 65 again. At the same time, the law states that every 5 years this limit will be revised considering changes of life expectancy. Nevertheless, as this revision is crucially dependent on action of the Government and the Parliament, we assume, in accordance with the current law and no-policy-change principle, increase of retirement age up to 65 years and constant thereafter.

However, the model works with yearly data, therefore the evolution of the statutory age is not so smooth. This causes the erratic development in case of data for new pensions. There are still differences in retirement age not only in case of sexes, but for women the number of children raised matters, too. For the modelling purposes we work with an average woman that brought up 2 children.

Figure 1: Evolution of Statutory Retirement Age in the Model



Source: Ministry of Finance based on Act No. 155/1995 Coll. on Pension Insurance, as amended.

The presented methodology deals only with the first pillar in the Czech Republic, which is a mandatory basic pension insurance scheme, based on the pay-as-you-go financing and defined benefits. It covers all economically active persons and it does not contain any special pension scheme for any economic sector. The only exceptions are miners,

who have lower retirement age, otherwise the system is the same. The state pension system covers three main benefits – old-age, disability and survivor's pensions. The pension projections consider all three kinds of benefits.

To be entitled to an **old age pension** a person has to reach an insurance period of at least 35 years and a retirement age specified by law; or at least 20 years of insurance and the age 5 years higher than is the statutory retirement age. Non-contributory periods are also included in the insurance period. The statutory retirement age is specified with regard to person's date of birth and children raised (just in case of women) until it reaches 65 for all persons regardless the number of children brought up. However, every 5 years the Government is to be provided by the Report on Pension System assessing changes in demography and life expectancy. If there is a significant change in life expectancy, the Government would decide about rising the statutory retirement age in the way assuring that 25% of life is spent in retirement. Changes in retirement age concern just the people at the ages of 25 up to 54.

A person is allowed to retire up to 3 years prior the statutory retirement age under the condition the statutory retirement age is lower than 63 years. This period of 3 years will gradually lengthen up to 5 years prior the statutory retirement age if the condition of insurance period is fulfilled. However, in the latter case the statutory retirement age must be at least 63 years and the actual age of the person not less than 60 years. This means that only a person with the statutory retirement age at (least) 65 years may retire 5 years earlier. In such case of earlier retirement, the person obtains permanently reduced early old age pension. Retirement in ages higher than the statutory retirement age is awarded by additional bonuses.[1]

Disability pensions are received by persons whose ability to work is reduced by at least 35% and are divided into three ranges: (i) first degree of disability – when a person has experienced a decline in his/her working capacity of at least 35% but not more than 49%; (ii) second degree of disability – a decline of at least 50% but not more than 69%; (iii) third degree of disability – a decline of at least 70%. The required insurance period is at least 5 years (it is derived from the ten-year period prior to the occurrence of disability).

Disability pension belongs to a person until his/her working ability improves, or until he/she reaches entitlement for the old age pension given by the statutory retirement age. Subsequently, the person is transferred from the disability pension scheme to the old age pension scheme.

For the purpose of projection, people can be disabled only in ages under 65. At 65 they are automatically transferred to old-age pensions. Evolution of disability rates is stable over the horizon as illustrated in Table 1 (for graphical profiles, see Annex B).

Table 1: Disability Rates According to Age
(In %)

	2016	2020	2030	2040	2050	2060	2070
Age group -54	3.4	3.4	3.6	3.5	3.3	3.4	3.4
Age group 55-59	15.5	14.4	13.8	13.8	14.2	14.2	14.3
Age group 60-64	11.5	11.4	10.3	9.9	10.0	10.2	10.4
Age group 65-69	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Age group 70-74	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Age group 75+	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Ministry of Finance calculations.

Survivor's 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 he/she died due to job-relating injury. After one year of receiving the survivor's pension, the widow/widower must meet other conditions stipulated by law, otherwise the entitlement lapses (the entitlement continues when the widow/widower cares for a dependent child or disabled child, parents or relatives aged 80 and higher; or when a widow/widower is disabled in the third degree of disability or retired; or he/she has reached the age, which is 4 years lower than the statutory retirement age of men of the same year of birth). The entitlement is also renewed when at least one of these conditions is met within 2 years from the last entitlement termination. An orphan's entitlement to survivor's pension lasts while he/she is dependent. If the adoption is made by only one person, the orphan loses that part of the pension after the person being now replaced (i.e. if an orphan is adopted only by a woman, the orphan loses pension on behalf of absent mother).

[1] It is worth noting that 5 years before reaching the statutory retirement age a person is allowed to draw, a so-called preretirement pension from 3rd pillar (voluntary fully funded private system) without imposing any sanctions. However, preretirement is conditional upon having a minimum amount of accumulated funds in the private 3rd pillar so as to provide a monthly pension amounting to at least 30% of the average wage. The old-age pension will not be subsequently reduced for the years when the pre-pension is drawn. The possibility to draw preretirement was only used by 2,676 persons before the end of 2017 (comparing to 274 in 2013). As to the sustainability of the pension system, the impact of this measure is negligible.

1.3 Pension Calculation and Indexation

The pension system in the Czech Republic shows a high degree of solidarity. Besides the pay-as-you-go principle, in which economically active persons are solidary with the pensioners, the pension calculation itself is significantly equalitarian through the reduction thresholds. The personal assessment base (which is understood as a pensionable earning in the projections) is determined by the income and the income is divided by reduction thresholds to several reduction brackets. Only the lowest part as 1st reduction bracket (up to 44% of average wage) is taken whole and other parts (from 44% of average wage to 400% of average wage is the 2nd bracket) of the income only by decreasing percentage. Actual values are valid from 2015 onwards: the 1st bracket 100%, the 2nd bracket 26% and 0% above. It is equivalent to sharp progressive taxation.

The indexation of pensions paid from the pay-as-you-go system is determined as a sum of consumer or pensioner price index growth (whichever is higher) and one half of real wage growth. This regulation applies from 1 January 2018. Previously, the indexation formula was a sum of consumer price index growth and one third of real wage growth. Moreover, given the low inflation rate in the recent past, a change in the indexation of pensions was approved that, with effect from 2017, returned limited discretion to the government. Should the increase in the average pension not reach 2.7% under the standard indexation formula, the government may order indexation of pensions up to that value. In other cases, it is proceeded strictly in accordance with the statutory indexation formula. For the purposes of the projection modelling, it is assumed that consumer price index and pensioner cost of living index growths are the same and thus taken just consumer price index from the agreed macroeconomic assumptions. As the inflation rate is taken to be 2% over the projection horizon, which is in line with a Czech National Bank's inflation target as well as a target of the European Central Bank, and a real wage growth at least 1.5%, the discretion does not step in.

1.3.1 Pension Taxation

Pension benefits are not taxed in absolute majority of cases. This is due to a high threshold up to which income of pensioners is tax exempt. Only pension benefits exceeding 3 times minimum wage are subject to 15% personal income tax. Currently not even 1% of pensioners pays taxes from pensions. Moreover, such negligible personal income tax revenue is a source of the state budget and not of the social security system itself. For these reasons tax calculations are not part of projection exercise.

1.4 Contributions

Public pension contributions are paid by working population from their wages, which develop in line with GDP over the horizon. We assume a constant contribution rate, which equals to 28% as stipulated by law. Contribution burden is shared between an employee (6.5%) and the employer (21.5%). This results in the constant share of contributions on GDP in all projection years.

2 Pension Model

The model makes distinction among various pension benefits (old-age, disability, widows'/widowers' and orphans'), sexes (males, females) and generations (the year of birth).

In accordance with the Czech legislation, the model explicitly differentiates between several types of pensions:

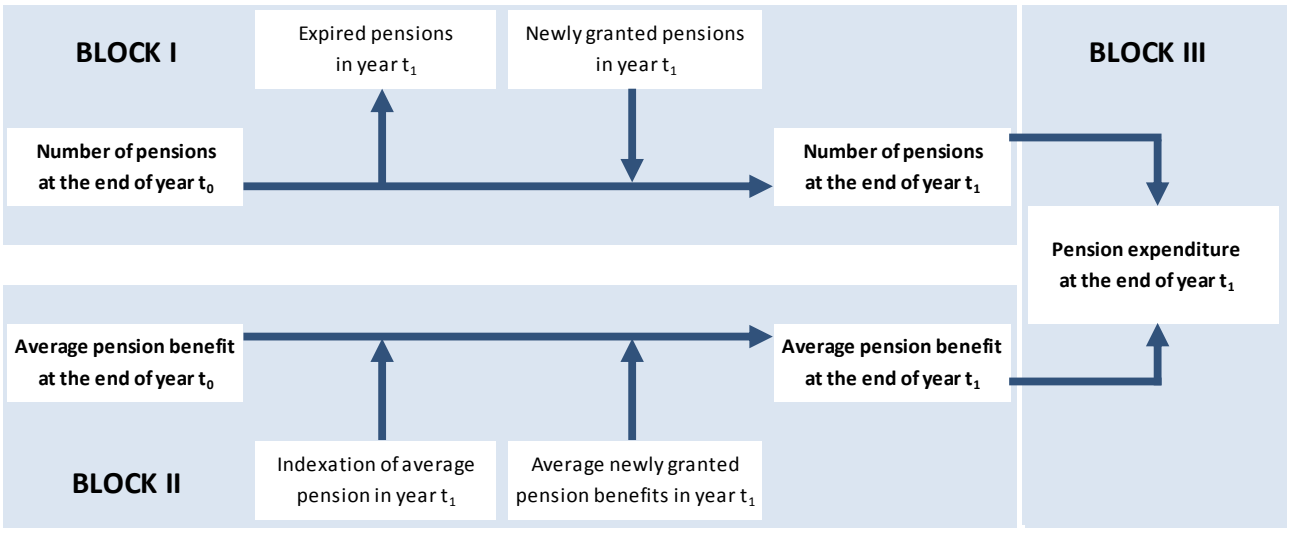
- old-age pensions (including early retirement old-age pensions, which can be granted up to five years prior to the statutory retirement age),
- disability pensions (distinguishes between all three types: 3rd degree – when working capacity is reduced by at least 70%, 2nd and 1st degree – with working capacity reduced by 50– 69% and 35– 49%, respectively,
- widow's/widower's pensions solo,
- widow's/widower's pensions in concurrence with other pensions (disability, old-age),
- orphan's pensions.

The distinction between males and females enables to differentiate in the earnings profiles, length of their career and contribution periods. These differences result in diverse level of pension benefits. It is also important to apply cohort approach since the cohorts (generations) are not homogenous. Generations (identified by the year of birth) differ in some important characteristics, e.g. mortality rates (impacts for instance the number of survivors´ pensions or the average lengths of receiving an old-age pension), disability rates (impacts the number of disability pensions) and affiliation with a generation is also decisive for determination of the statutory retirement age.

The model primarily works with the number of pensions, not with the number of pensioners. The number of pensioners is lower than the number of pensions since some pensioners may be entitled to receive two types of pension benefits. According to the Czech pension legislation, recipients of disability or old-age pensions may under given conditions receive widow's/widower's pension at the same time. Thus, the number of pensioners can be obtained by subtracting the number of widow's/widower's pensions in concurrence with other pensions from the total number of pensions. The ratio between pensioners and pensions is stable over time amounting to 80%–86%.

The model consists of three main building blocks, which are illustrated on Figure 2. The first block calculates the number of pensions and flow of new pensions. The second one computes the level of new pension benefits. The third block combines the information on the stock and flow of pensions with the projection of new pension benefits which gives the evolution of an average pension benefit and spending on all pension benefits in the projection horizon. All blocks work directly with generational data, so we are still able to distinguish between males, females, single ages, years of birth and calendar years.

Figure 2: Simplified Structure of the Model



Source: Ministry of Finance.

2.1 Block I – Number of Pensions[2]

The number of pensions is calculated on the basis of the cohort methodology. The computation stems from the idea, that there is a certain probability that an individual of a given age and sex and from given cohort retires, becomes disabled, orphan, widow or widower.

2.1.1 Old-age and Disability Pensions

First of all, we stem from observed age specific shares and probabilities and assume their evolution in the future. Age specific shares of respective pension (*pen_s*)[3] are given by the number of pensions (*pen*) on population (*pop*) for each calendar year (*t*), age (*a*) and sex (*s*).

$$pen\_s_t^{a,s} = \frac{pen_t^{a,s}}{pop_t^{a,s}} \tag{1}$$

This allows us to calculate conditional probability of becoming a beneficiary of the respective pension (*pen_p*) as illustrated by equation (2). All pensions except the old-age can be terminated, when the pensioner changes its status, e.g. disability pension can be ended due to renewed working capacity or becoming entitled to old-age pension.[4] The conditional probability that a person ceases to be a pensioner can be expressed as in (3).

$$pen\_p_t^{a,s} = \begin{cases} \dfrac{pen\_s_t^{a,s} - pen\_s_{t-1}^{a-1,s}}{1 - pen\_s_{t-1}^{a-1,s}}, pen\_s_t^{a,s} - pen\_s_{t-1}^{a-1,s} \geq 0 \\ -\left(1 - \dfrac{pen_{s_t}^{a,s}}{pen_{s_{t-1}}^{a-1,s}}\right), pen\_s_t^{a,s} - pen\_s_{t-1}^{a-1,s} < 0 \end{cases} \tag{2}$$

Such shares and probabilities for the base year are then transformed from dimension age/calendar year into age/generation[5]:

$$pen\_s_t^{a,s} \rightarrow pen\_s_t^{g,s}, \qquad pen\_p_t^{a,s} \rightarrow pen\_p_t^{g,s} \tag{3}$$

and projected into the future.[6] Projecting probabilities, continuously increasing the statutory retirement age (until the adjustable age ceiling is reached, see Section 3.1) must be considered. Therefore, in case of old-age, each generation with higher retirement age than the base generation takes the probability of retirement from a person who is (or was at the time of retirement of his/her generation) as many years younger as the difference in their retirement ages, i.e. in such case:

$$pen\_p_{g+a+(ret^{g,m} - ret^{1953,m})}^{g,m} = pen\_p_{1953+a}^{1953,m} \quad \text{and} \quad pen\_p_{g+a+(ret^{g,f} - ret^{1956,f})}^{g,f} = pen\_p_{1956+a}^{1956,f} \tag{4}$$

for males (*m*) and females (*f*). Such splitting is done in ages where probability profiles are flat (depending on the type of pension). We stem from generations that retire in the base year 2016 (generation of men born in 1953 has retirement age equal to 63 years, i.e. 2016 = 1953 + 63, while the generation of women born in 1956 reaches the statutory retirement age also in 2016 = 1956 + 60).

Projected probabilities are then used to calculate shares on population for all future generations in accordance with (2) and (3).

$$pen\_s_{t+1}^{g,s} = \begin{cases} pen\_s_t^{g,s} \cdot \left(1 - pen\_p_t^{g,s}\right) + pen\_p_t^{g,s}, & pen\_p_t^{a,s} \geq 0 \\ pen\_s_t^{g,s} \cdot \left(1 - pen\_p_t^{g,s}\right), & pen\_p_t^{a,s} < 0 \end{cases} \tag{5}$$

Having derived this, it is straightforward to get numbers of old-age and all three disability types pensioners as a product of respective shares and population:

$$pen_{t+1}^{g,s} = pen\_s_t^{g,s} \cdot pop_t^{g,s} \tag{6}$$

[2] Graphs showing developments of numbers of pensions are in Annex B (Figure 21–Figure 27).

[3] *pen* represents here old-age (*oa*) and disability pensions of all three types (*dis3*, *dis2*, *dis1*); _s denotes share.

[4] Beyond the statutory retirement age all disability pensions are considered to be old-age pensions. As a result, disability pensions disappear after reaching the statutory retirement age.

[5] The notation may seem a bit tricky, as we keep the index *t* for calendar year even in the generational form. The explanation behind is that $t = g + a$ and in generational form we keep *g* fixed, thus all shifts in *t* are translated into shifts of *a*.

[6] For illustration of age specific shares, see Annex B (Figure 9–Figure 20).

Summing this over generations and sexes, we obtain the total number of pensions for a calendar year.

$$pen_t = \sum_{g,s} pen\_s_t^{g,s} \cdot pop_t^{g,s} \tag{7}$$

2.1.2 Widows'/Widowers' Pensions

A different approach is used to calculate the number of survivors' pensions. The number of widow's pensions depends on the marital status, probability of a spouse to die in a given year and the compound probability of the couple to die within the same year. Moreover, we assume (on the basis of fairly stable mortality rates) that before the age a_0[7] ($a_0 = t_0 - g$) the profile of widow's/widower's pension is the same as in the base year. The share of widow's pensions on population (wid_s) after age a_0 is calculated as follows:

$$wid\_s_t^{g,f} = wid\_s_{t-1}^{g,f} + \varepsilon_{a+k}^{g+k,m} \cdot \left(1 - \varepsilon_a^{g,f}\right) \cdot \frac{mpop_{t_0}^{g,f}}{pop_{t_0}^{g,f}} - \varepsilon_a^{g,f} \cdot \left(wid\_s_{t-1}^{g,f}\right) \tag{8}$$

where ε stands for mortality rate and *mpop* is the number of married population. The same relation similarly holds for men. Since married couples are not necessarily of the same age, ε of the other sex should be viewed as an average mortality rate of the other sex of given generation $g+k$ around the corresponding age $a+k$, where k is the average age difference in a legal union (computed for the base year t_0).

The number of widow's/widower's pensions is further split into the solo pensions (*wids*) and pensions in concurrence (*widc*) with other pensions (old-age and disability) according to the probability that the person is a recipient of old-age or disability pension, which is given by the fraction of population that receives old-age (*oa*) or disability pension (*dis = dis1 + dis2 + dis3*).

$$wids_t^{g,s} = wid_t^{g,s} \cdot \left(1 - \frac{oa_t^{g,s} + dis_t^{g,s}}{pop_t^{g,s}}\right) \tag{9}$$

$$widc_t^{g,s} = wid_t^{g,s} \cdot wids_t^{g,s} \tag{10}$$

2.1.3 Orphans' Pensions

The number of orphan's pensions (*or*) is projected simply on the basis of the existing profile (age and sex specific ratio of orphan's pensions to population) since mortality rates for those aged less than 26 are not subject to any major changes. With respect to their limited importance, this seems to be a good approximation, i.e. shares on population are the same in all years as in the base year:

$$or\_s_t^{a,s} = or\_s_{2016}^{a,s} \tag{11}$$

The number of pensions is calculated similarly for other pension types

$$or\_s_t^{a,s} = or\_s_t^{a,s} \cdot pop\_s_t^{a,s} \tag{12}$$

2.1.4 Newly Granted Pensions (All Types of Pensions)

The number of new pensions (*npen*) in generation g and sex s is consistent with the stock of pensions (*pen*), from which it is computed with the use of the probability of survivorship derived from sex and generation specific mortality rate (ε)

$$npen_t^{g,s} = pen_t^{g,s} - pen_{t-1}^{g,s} \cdot \left(1 - \varepsilon_t^{g,s}\right) \tag{13}$$

Unfortunately, there is no such straightforward relationship in the case of disability pensions since a disability benefit is withdrawn when the working capacity is restored. Thus, the number of new pensions computed according to (13) would be underestimated and spending on disability benefits and an average benefit would be lower (under the assumption of indexation lower than the wage growth).

$$ndis_t^{g,s} = k_{g+a}^{g,s} \cdot dis_t^{g,s} \tag{14}$$

$$k_{g+a}^{g,s} \equiv k^{a,s} = \frac{ndis_{2016}^{a,s}}{dis_{2016}} \tag{15}$$

[7] After this age the entitlement for widow's/widower's pension is permanent (i.e. till the end of one's life) as opposed to the age before when the entitlement is only temporary (it lasts a year). The legislation sets the age to be four years before the statutory retirement age and as such it will rise with the postponement of this benchmark.

The model assumes a fixed relationship between the number of new pensions and the stock of pensions in a given age (*a*) and the ratio was calibrated on the basis of 2016 data[8].

2.2 Block II – Average Newly Granted Pension Benefits

This block enables to (i) assess the impact of the government decisions (pertaining to the indexation of the main parameters of the pension formula) on the level of newly granted pensions in the short run and (ii) simulate the impact of changes in the pension formula in the long run.

The changes in pension formulae are simulated in a matrix with two dimensions – assessment basis and contribution period. It is a matrix, which gives the number of pensions for a given combination of personal assessment basis (average earnings during the contributory period) and contributory period. We assume that the distribution of pension numbers within this matrix will be shifted in terms of contributory periods in accordance with postponement of retirement and the extension of acknowledged contributory periods for the whole career.

Having such distribution, it is possible to compute a pension benefit for each cell of the matrix for each projection year on the basis of the pension formula (equations 16–18). Weighing the pension benefits by the number of recipients gives the average newly granted pension.

$$npen_v = frc + erc \tag{16}$$

$$erc = \left\{ \begin{matrix} \min(pab, rb_1) \cdot rc_1 + \\ +\max[\min(pab - rb_1, rb_2 - rb_1), 0] \cdot rc_2 + \\ +\max[pab - rb_2, 0] \cdot rc_3 \end{matrix} \right\} \cdot \frac{cp_1 + cpr \cdot cp_2}{365} \cdot ar \tag{17}$$

$$pab = \frac{\sum_{y=Y-1-\min(car,Y-1-1986)}^{Y-1} ycb_y \cdot \prod_{t=y}^{Y-1} \frac{w_{t+1}}{w_t}}{\min(car, Y-1-1986) - \frac{ncp}{365}} \tag{18}$$

npen_v stands for newly granted pension benefit, *frc* for flat rate component (since 2019 it is 10% of average wage), *erc* earnings related component, *pab* personal assessment base, *rb* reduction brackets (44% and 400% of average wage respectively), *rc* reduction *coefficient* (currently rc_1 = 100% up to rb_1, rc_2 = 26% up to rb_2), *cp contribution* period up to the statutory retirement age in days (including non-contributory periods assessed as if contributory but only up to certain contributory period rate *cpr* = 80%), *ar* accrual *rate* (1.5%), *car* years of career, *Y* year of *retirement*, *ycb* yearly assessment basis[9] in present value calculated on the basis of index derived from the growth rate of average wage in the economy (*w*) and *ncp* is for excluded non-contributory periods.

The description concerns mainly old-age pensions. In fact, the same procedure is used for other pension benefits with minor changes in the pension formula.

2.3 Block III – Average Pension and Total Pension Spending

In the base year the average pension benefit (for all types of pensions) is reported for each age and sex by the Czech Social Security Administration. It then enters the equation computing total pension expenditure. Total spending on a given type of pension (*pen_e*) in equation 19 is a function of the average pension benefit (*pen_v*) from the previous year indexed in accordance with the pension legislation (*index*), the value of newly granted average pension benefit (*npen_v*) calculated in the Block II of the model, and the number of pensions (*pen*) and newly granted pensions (*npen*) from the Block I.

$$pen\_e_t = \sum_{g,s} \left(pen_t^{g,s} - npen_t^{g,s} \right) \cdot pen\_v_{t-1}^{g,s} \cdot (1 + index_t) + npen_t^{g,s} \cdot npen\_v_t^{g,s} \tag{19}$$

Total pension expenditure is simply a sum of the pension spending on all the pension types.

In the projection horizon the average pension benefit (*pen_v*) for a given generation *g* and sex *s* is calculated on the basis of the pension spending (*pen_e*) and the number of pensions (*pen*). The average pension in respective year of projection is a weighted average of average pension from the previous period and the newly granted pension benefits

[8] That is, the model assumes a constant probability of restoring the working capacity.

[9] Current legislation of the pension system takes into consideration all career years but not those before year 1986.

$$pen\_v_t^{g,s} = \frac{pen\_e_t^{g,s}}{pen_t^{g,s}} = \frac{\left(pen_t^{g,s} - npen_t^{g,s}\right)}{pen_t^{g,s}} \cdot pen_{v_{t-1}^{g,s}} \cdot (1 + index_t) + \frac{npen_t^{g,s}}{pen_t^{g,s}} \cdot npen\_v_t^{g,s} \quad (20)$$

Replacement rate of each pension type is simply a share of average pension benefit of paid out pension (*pen_v*), or newly granted pension (*npen_v*), over average gross wage at retirement (*aw_ret*)

$$pen\_rr_t^{g,s} = \frac{pen\_v_t^{g,s}}{aw\_ret_t}, \qquad npen\_rr_t^{g,s} = \frac{npen\_v_t^{g,s}}{aw\_ret_t}. \quad (21)$$

In order to estimate the relationship between economy wide average wage and average wage at retirement, we used the data of the Czech Statistical Office on wage distribution. We examine data for past years, which show relatively high inertia of the wage profile across the ages from 15 to 65+. This enables us to assume constant wage profile in the future. We assume the shift in the age specific wage profile from the base year onwards with respect to postponement of retirement age and thus constant relationships to average wage. This means that the average gross wage at retirement grows exactly at the same pace as the average wage given by the Ageing Working Group's assumptions and is approximately by 3.7% higher than economy wide average wage (in 2017 projections). We work with the average wage, equal for men and women. This fact does not have an impact on pension projection results as benefits are calculated based on detailed data about gender specific personal assessment bases and contributory periods. Thus, usage of the unisex wage profiles may have some impact on results of replacement rates only.

Table 2: Economy-wide Average Wage at Retirement

(In thousands of euro)

	2016	2020	2030	2040	2050	2060	2070
Economy-wide average wage	12.3	14.7	22.3	32.9	47.9	68.9	98.2
Economy-wide average wage at retirement	12.8	15.3	23.1	34.1	49.6	71.4	101.8

Note: European Commission project economy-wide average wage for EU countries in EUR. Economy-wide average wage at retirement is by 3.7% higher as calculated from data of the Czech Statistical Office. For recalculation to CZK, constant exchange rate over time is used as agreed in methodology of long-term projection exercise.

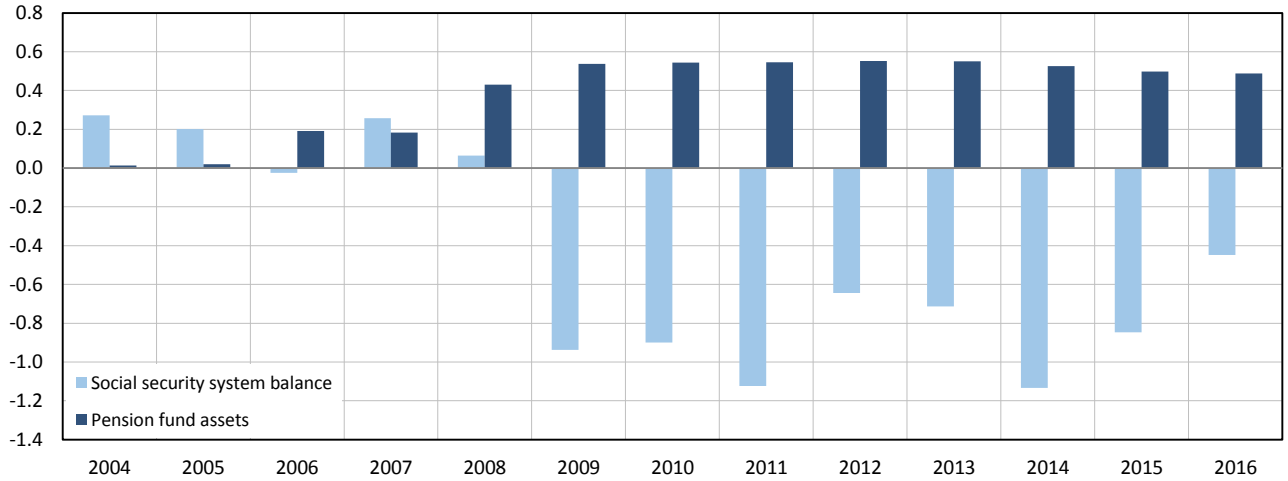
Source: European Commission, Ministry of Finance calculations.

3 Conclusion and Main Results

Figure 3 shows the evolution of the balance and assets of the pension fund up to the year 2016 (base year for the 2017 projections). Figure 4, on the other hand, presents the results of pension projections about the system's balance, revenue and expenditure for the sake of the sustainability analysis.[10] Social security system balances illustrate annual differences between contributions and expenditures paid out to all types of pensioners (it is the flow variable). Besides the social contributions, some ad hoc inflows, e.g. from dividends paid by state-owned companies are transferred to the State budget to finance the deficit of the pension system. Pension fund assets variable shows the stock at the end of every year. These assets cannot be spent deliberately. This prevents the assets to be depleted and the deficits are covered from other government revenues in the State budget. Thus, the assets are real on the one hand, but on the other hand they are preserved just according to law but virtually would be already exhausted. This is assumed for the future as this reflects the economic reality of the pension account, i.e. the system itself does not accumulate assets from the past. In case the legislation is changed in this respect, the results are, thus, not to be affected.

Figure 3: Social Security Balance and Pension Fund Assets

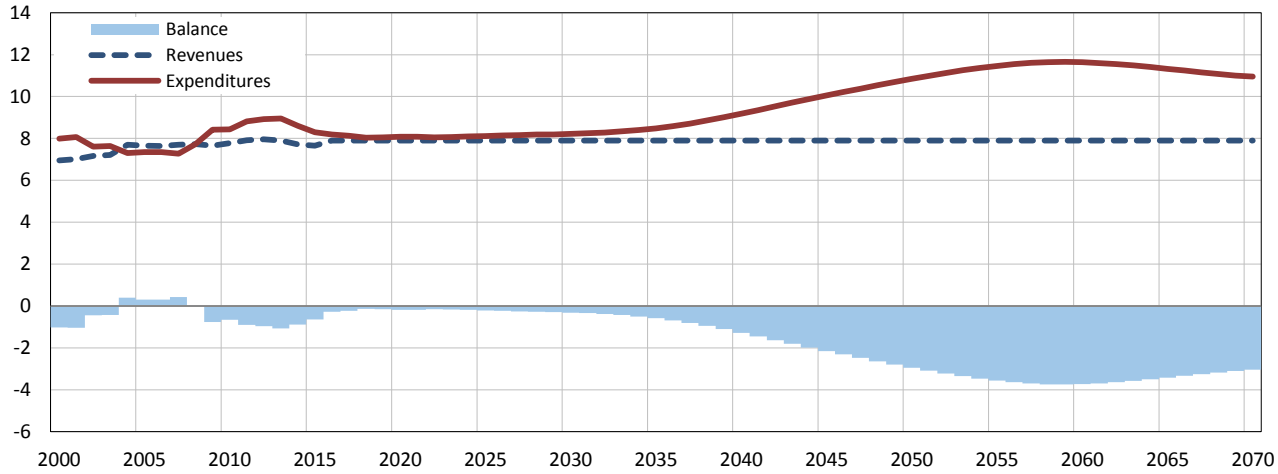
(% of GDP)



Source: Ministry of Finance.

Figure 4: Revenues, Expenditures and Balance

(% of GDP)



Source: Ministry of Finance calculations.

Regardless of differences in the levels of individual assumptions, it is possible to discern from the course of trends and their mutual links certain characteristics or features that repeat. Approximately until the mid-2030s, expenditures should develop rather favourably, whereupon will follow an increase in expenditures on pensions due to demography.

[10] Note that the results are here just for illustration and are not explained. Explanation can be found in MF (2017), Convergence Programme of the Czech Republic (https://www.mfcr.cz/en/statistics/convergence-programme) or several information papers (https://www.mfcr.cz/en/about-ministry/research#information) published on the web site of Ministry of Finance.

Nevertheless, projected expenditures already reach maximum values in 2059 and reversal and subsequent decrease in expenditures after 2060 takes place.

3.1 Sensitivity Analysis

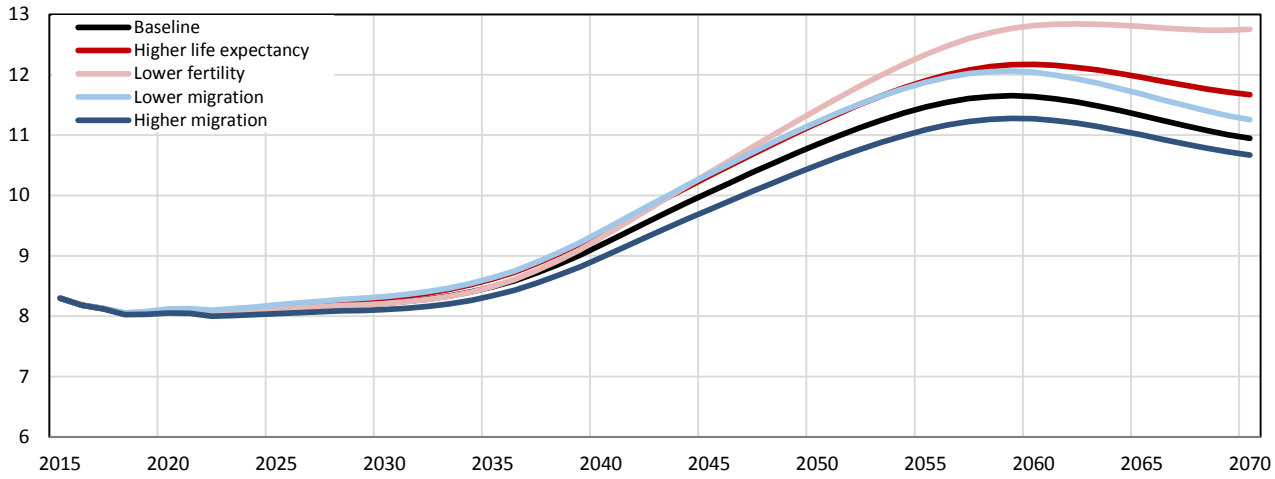
Baseline scenario results give clear view about how trends in population structure can influence total pension expenditure in the long term. Necessary assumptions made about underlying demographic and macroeconomic scenario are, however, subject of uncertainty. Therefore, the projection results are supplemented with various sensitivity scenarios.

3.1.1 Demography

Compared with the baseline projection four alternative demographic scenarios assume (i) increase of life expectancy at birth of about two years by 2070 compared with the baseline assumptions, (ii) 20% lower fertility over the entire projection term, (iii) 33% less net migration and (iv) 33% more net migration. Results are summarized in following Figure 5.

Figure 5: Sensitivity on Key Demographic Parameters

(% of GDP)



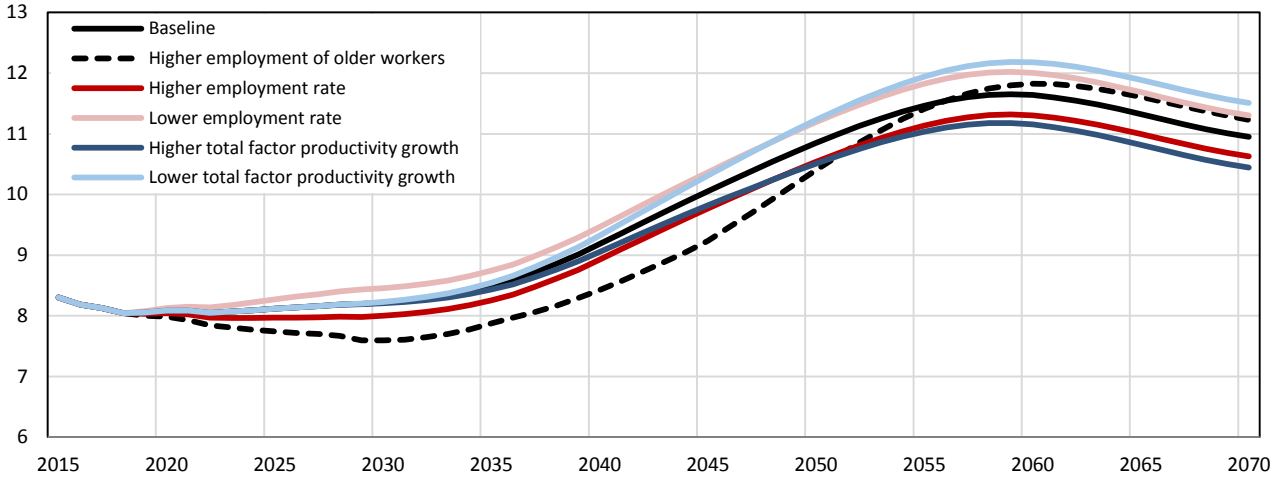
Source: Ministry of Finance calculations.

3.1.2 Macroeconomic Scenario

Macroeconomic alternatives focus on labour force assuming (i) higher employment rate of older workers aged 55–74 by 10 p.p. comparing with baseline assumptions, (ii) 2 p.p. higher and (iii) 2 p.p. lower employment rate for the age group 20–64. In terms of productivity (iv) TFP growth is assumed to converge to 0.4 p.p. higher and (v) to 0.4 p.p. lower growth rate in in 2045, while baseline assumption relies on convergence of TFP growth to 1% in that year.

Figure 6: Sensitivity on Key Macroeconomic Parameters

(% of GDP)



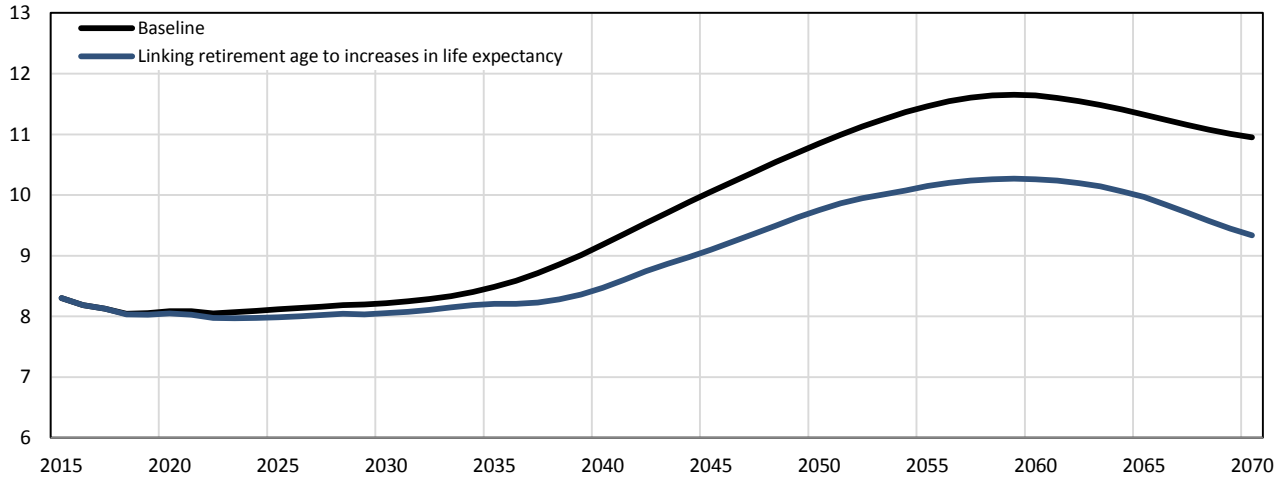
Source: Ministry of Finance calculations.

3.1.3 Policy Scenario

The policy scenario employs the assumption of shifting the statutory retirement age year-over-year in line with change in life expectancy at retirement age. It mimics the system where the retirement age is linked to longevity, which in fact replicates development of our pensionable age in case that all future governments would always approve the review mechanism inbuilt in our legislation.

Figure 7: Effect of Linking the Retirement Age to Life Expectancy Gains

(% of GDP)



Source: Ministry of Finance calculations.

References

Act No. 155/1995 Coll. on Pension Insurance, as amended.

Bělohradský, A. (2018): The Methodology of Health Care, Long term Care and Education Projections. Prague, Ministry of Finance of the Czech Republic, Methodological Compendium, December 2018.

EC (2017): The 2018 Ageing Report: Underlying Assumptions and Projection Methodologies. Luxembourg, European Commission, Institutional Papers No. 065, November 2017, [cit. 29/3/2018], <https://ec.europa.eu/info/sites/info/files/economy-finance/ip065_en.pdf>.

EC (2018): The 2018 Ageing Report: Economic and Budgetary Projections for the EU Member States (2016–2070). Luxembourg, European Commission, Institutional Paper No. 079, May 2018 [cit. 13/11/2018], <https://ec.europa.eu/info/sites/info/files/economy-finance/ip079_en.pdf>.

MF CR (2012): Czech Pension Projections – A 2012 Update. Prague, Ministry of Finance of the Czech Republic, Information paper 2/2012, June 2012, [cit. 5/12/2018], <https://www.mfcr.cz/assets/cs/media/Odborne-vyzkumy_2012-06_CZECH-PENSION-PROJECTIONS-A-2012-UPDATE.pdf>.

MF CR (2015): 2015 Pension Projections Update. Prague, Ministry of Finance of the Czech Republic, Information paper 2/2015, September 2015, [cit. 5/12/2018], <https://www.mfcr.cz/assets/cs/media/Odborne-vyzkumy_Studie_2015-02_2015-Pension-Projections-Update.pdf>.

MF CR (2017): Pension Projections of the Czech Republic. Prague, Ministry of Finance of the Czech Republic, October 2017, [cited 5/12/2018], <https://ec.europa.eu/info/sites/info/files/economy-finance/final_country_fiche_cz.pdf>.

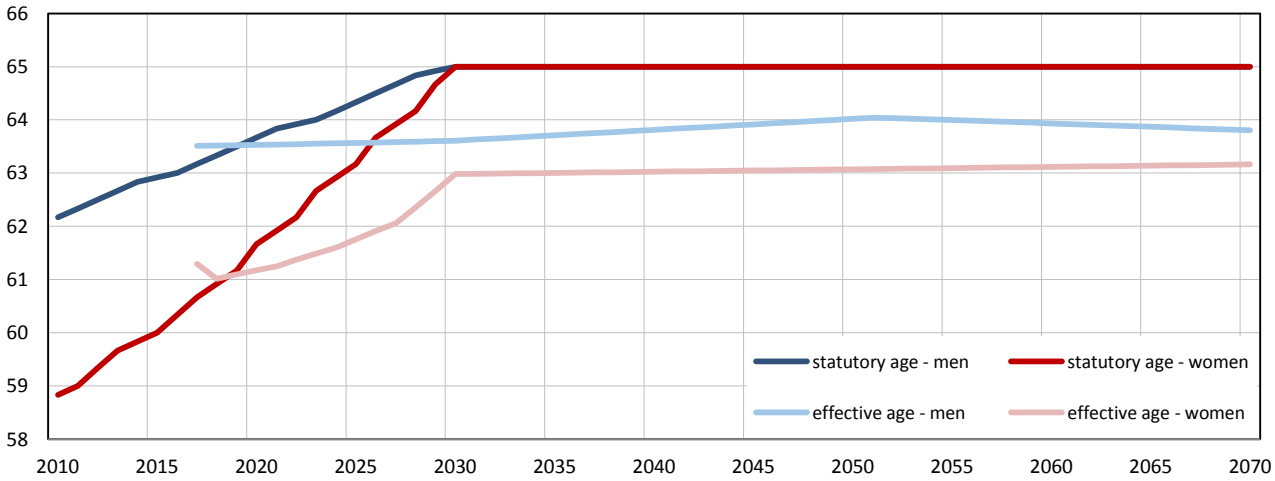
A Annex: Coverage Rate Adjustments

This annex aims at shedding some light on differences between the pension model and the Cohort Simulation Model used by the European Commission for creating macroeconomic framework of projections. Naturally, there are and will be reasonable differences between the two models by definition. Therefore, it requires more explanation, how the pension model has been adjusted, in order to meet common demographic and macroeconomic assumptions.

Statutory Retirement Age vs. Effective Retirement Age

What causes the problem with coverage rate decline is the difference between the statutory retirement age and effective retirement age assumed by Cohort Simulation Model. The Czech Republic has legislated increase in the statutory retirement age up to 65 years as shown in the following Figure 8. Although the retirement age is assigned to each generation (according to the year of birth), with a simple calculation, it can be assigned to calendar years as depicted by solid lines for men and women. This retirement age postponement is crucial for the pension model, which shifts the profiles of pensions according to that, as shown in Equation 4.

Figure 8: Statutory Retirement Age vs. Effective Exit Age in Cohort Simulation Model Assumptions



Source: Ministry of Finance based on Act No. 155/1995 Coll. on Pension Insurance, as amended; European Commission.

On the other hand, macroeconomic assumptions work with effective retirement. It is assumed that with an increasing retirement age there will be a weaker link between the two ages, i.e. the higher the retirement age, the more people will tend to leave labour market earlier.[11] Thus the share of inactive people over population increases.

Pension Model Adjustments

The pension model, as was introduced above, respects current legislation and shifts profiles with respect to the statutory retirement age, which is the only relevant age for e.g. old-age pension entitlements. On the other hand, there is an automatic adjustment from the disability pensions' scheme. As visible in quoted Figures, the share of disabled people in population increases with age. This increase and shifts of profile stem from past observed data.

However, the pension model incorporates additional adjustments in order to consider commonly agreed assumption to the highest possible extent. But at the same time, it is important to stick to the assumption of no-policy change projections. With this regard, the only solution seems to assume that people will opt much more for early retirement as the pension age increases. Therefore, the model takes the initial result of projection of numbers of pensions and calculates numbers of uncovered inactive people. Further on, it analyses, whether a person could be entitled for early retirement pension. If yes, such a person is additionally assigned early retirement pension. In this respect we assume that this additional demand for early retirement increases with the proximity of the statutory age. The problem is that old age pensions are, in case of some ages and cohorts (namely 55–59), unable to cover additional inactive people, as they are not allowed even for early retirement.

In addition to that we expect that in line with this rationale more people will tend to withdraw their capital savings from 3rd pillar and opt for pre-retirement scheme.

[11] However, recent data shows that it has not been the case as the effective retirement age develops with the statutory retirement age. This is mainly due to very strict and painful penalizations for early retirement.

There are not additional adjustments made in other types of pensions, e.g. in disabilities. Last observed data and the reform effective since 2010 show strong effect of tightening eligibility conditions in order to limit possible leaking from labour market. To use disability pensions for increasing coverage, it would require quite substantial jumps in disability profiles. This would violate the rule of no policy change.

Effects of Additional Coverage on Pension Results

Beside the improvement in ratio of pensioners over inactive people, model adjustments have other impacts on results. Early retirement pensions mean lower benefits for the early pensioners. Certain reductions apply amounting to more than quarter of an earnings-related pension benefit in case of earliest possible retirement. The additional assumption of higher demand for early retirement as the age approaches the statutory retirement age seems reasonable, because not many people would accept dramatic penalizations imposed when retiring at the earliest possible age.

If we assume that all inactive people would accept early retirement, it would result in unprecedentedly low replacement rates. And consequently, in decrease of total pension expenditure over time;[12] well below the current share on GDP at the end of projection horizon. Such projections would definitely not be reliable.

The early retirements affect also contributory periods, which are lower than if the statutory retirement age from the law would be followed. The career length departs from values observed in administrative data, i.e. 45 years for men and 42.5 years for women in 2016. Normally, development of these contributory periods should be in line with the statutory retirement age, i.e. higher retirement age by one year should increase contributory period also by additional year. However, if we assume that people will start to follow different path and retire earlier according to projected effective exit age from the Cohort Simulation Model, there will be more early retirees with shorter career and the average contributory period will not increase that much. Applying the same rule – career (and thus contributory period) increase by additional year when the effective exit age increases by one year. This is fully in line with Cohort Simulation Model assumptions, where average contributory period for men is constant simply because there is, in fact, no increase in effective age despite increasing the statutory retirement age. The same logic applies to women, where the increase is also limited because of increase of effective age only by three years.

One more thing is to be mentioned with respect to additional coverage. As the part of the population leaves the labour market earlier, the labour force shrinks and GDP in the projection is lower than would be the case the statutory retirement age is followed. In other words, the pension projection is lower but the same holds for the output. In total, the relative share of the projected pension expenditure is affected to minor extent.

[12] People would be assigned benefit earlier but on much lower permanent level. Total outlays for such a pensioner would be in sum lower than when assigned regular pension benefit later. This would drag the total pension expenditure down.

B Annex: Projection's Detailed Results

This annex brings an overview of detailed results so that the reader can better understand the results.

Cross Sectional Profiles – Age Specific Shares

The following figures show cross sectional profiles in specific years that reflect the calendar year, in which the statutory retirement age increases by one additional year. It is apparent that the process takes longer for women despite the faster speed (rise by 2 months a year for men compared to 4 months for women) until they reach the retirement age of men. It is a result of the much higher increase in the statutory age for women.

Figure 9: Old-age Pensions – Males

(Share of pensioners on population)

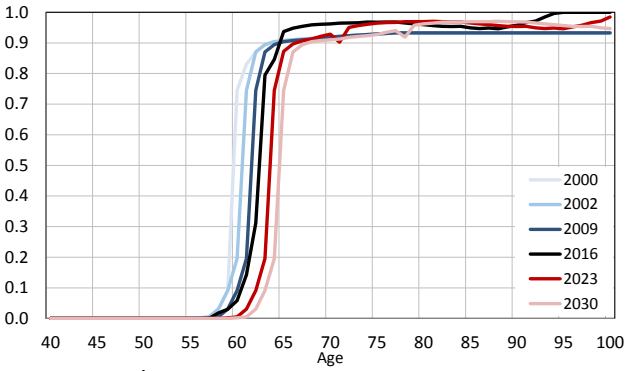


Figure 10: Old-age Pensions – Females

(Share of pensioners on population)

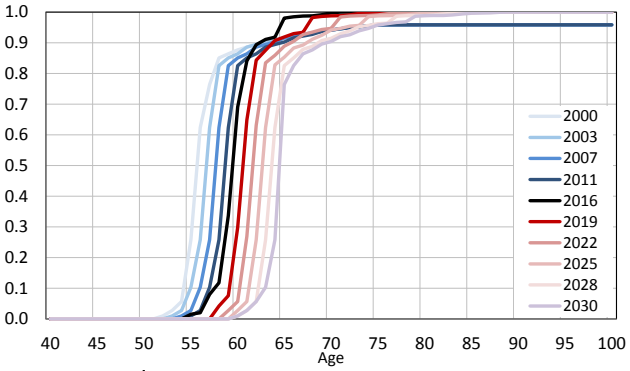


Figure 11: 3rd Degree Disability Pensions – Males

(Share of pensioners on population)

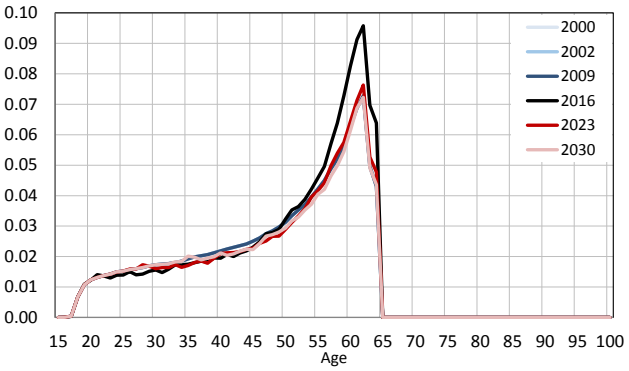


Figure 12: 3rd Degree Disability Pensions – Females

(Share of pensioners on population)

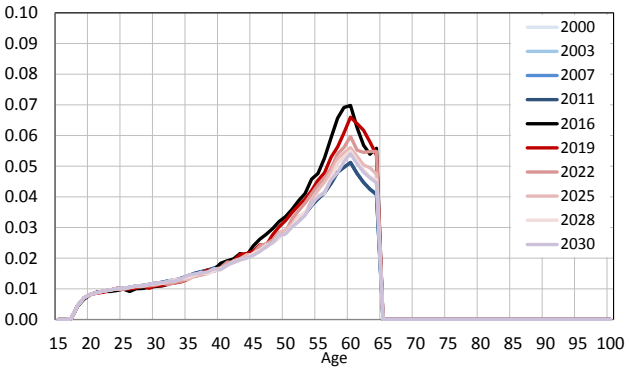


Figure 13: 2nd Degree Disability Pensions – Males

(Share of pensioners on population)

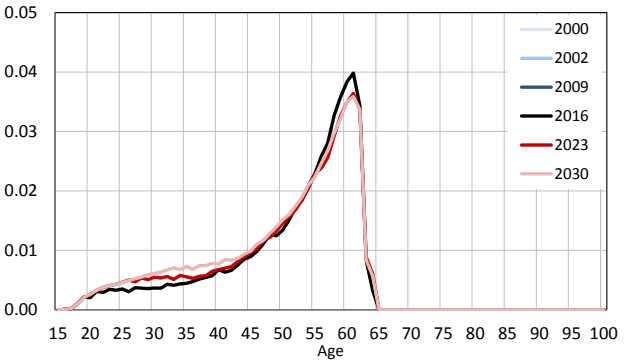
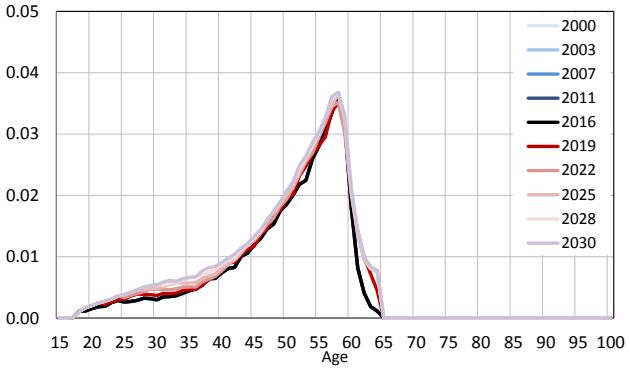


Figure 14: 2nd Degree Disability Pensions – Females

(Share of pensioners on population)



Note that minor changes in the peak of profiles for disability pensions for years at the beginning of projections are caused by generational effect of the 2010 reform. However, important feature of profiles – an increase of disability shares for pre-retirement ages – are clearly visible for projection years as retirement age increases.

Figure 15: 1st Degree Disability Pensions – Males

(Share of pensioners on population)

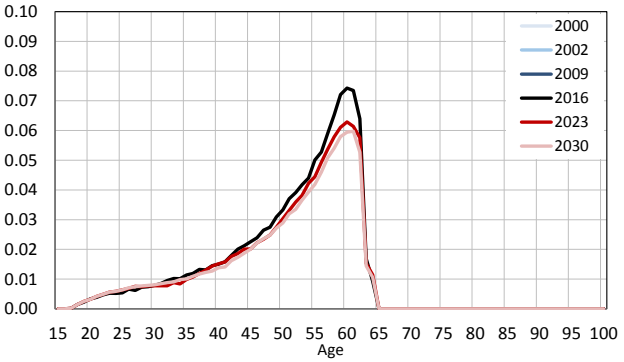


Figure 16: 1st Degree Disability Pensions – Females

(Share of pensioners on population)

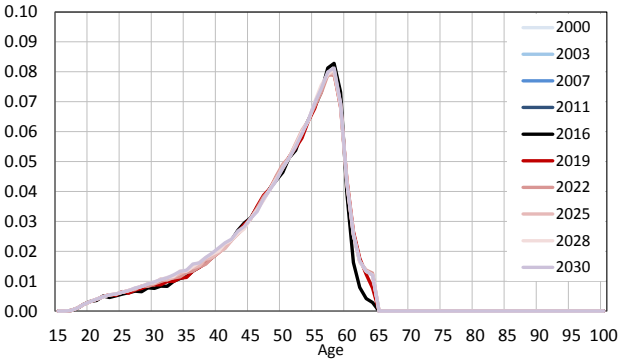


Figure 17: Widower's Pensions – Males

(Share of pensioners on population)

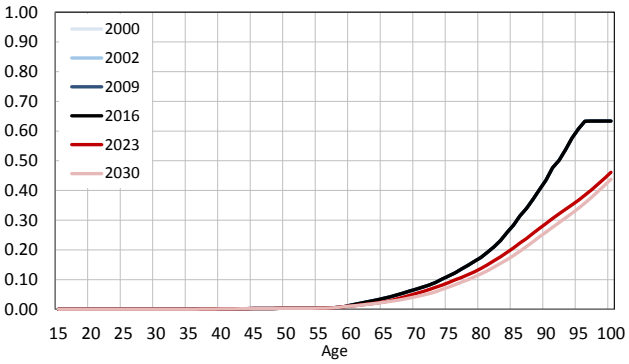


Figure 18: Widows' Pensions – Females

(Share of pensioners on population)

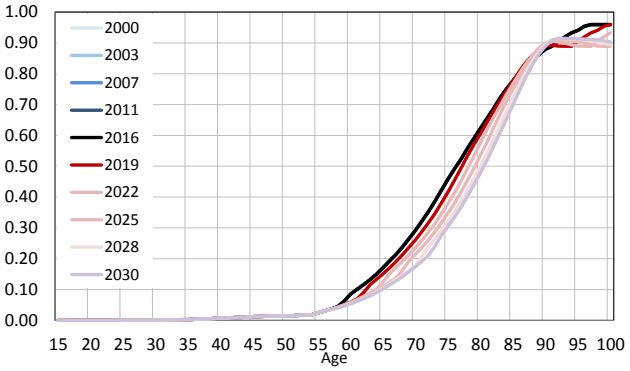


Figure 19: Orphan's Pensions – Males

(Share of pensioners on population)

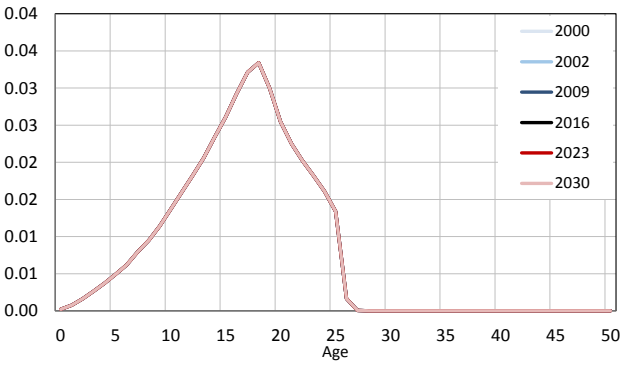
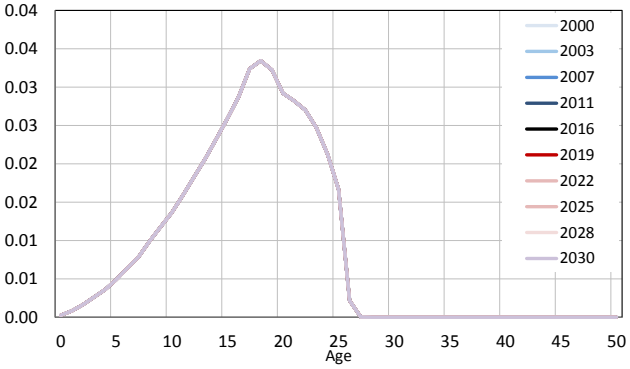


Figure 20: Orphan's Pensions – Females

(Share of pensioners on population)



Profiles of orphans' pensions do not change with the retirement age and are held constant for all years of projection.

Numbers of Pensions

Figure 21: All Pensions

(Millions)

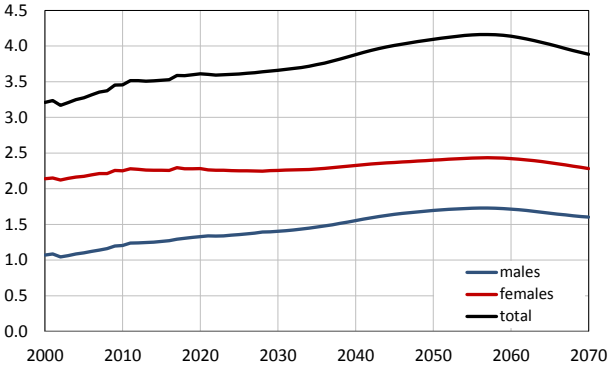


Figure 22: Old-age Pensions

(Millions)

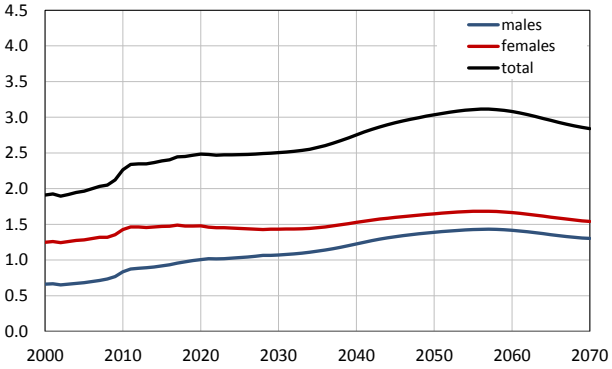


Figure 23: 3rd Degree Disability Pensions

(Thousands)

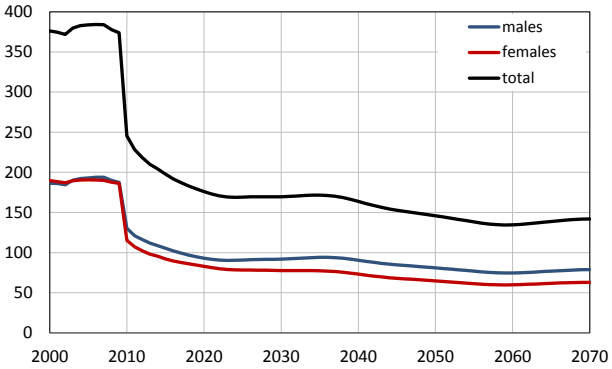


Figure 24: 2nd Degree Disability Pensions

(Thousands)

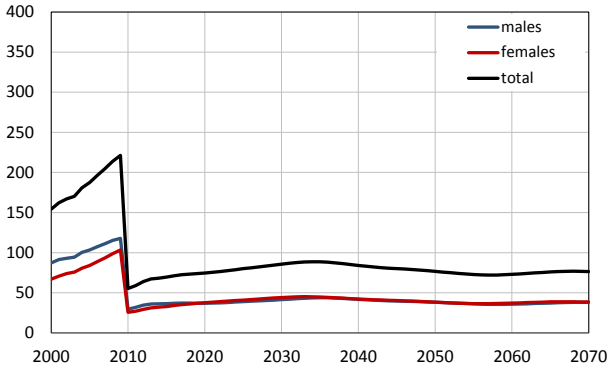


Figure 25: 1st Degree Disability Pensions

(Thousands)

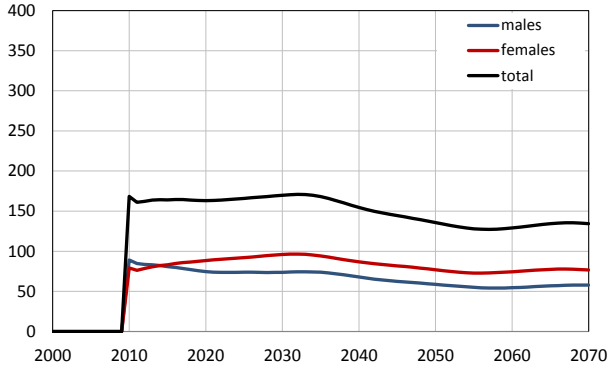


Figure 26: Widows'/Widowers' Pensions

(Thousands)

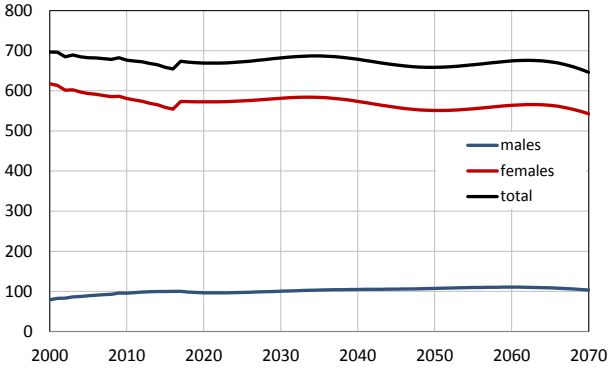
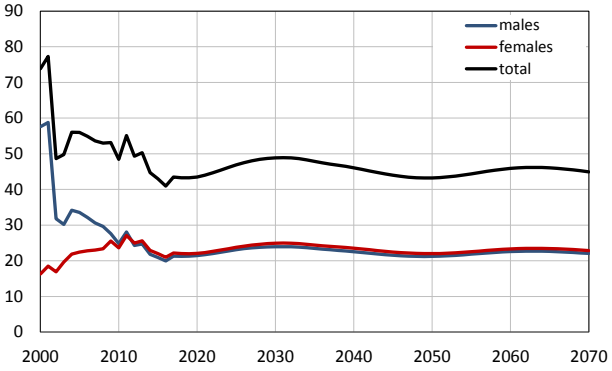


Figure 27: Orphans' Pensions

(Thousands)



Replacement Rates

Figure 28: All Pensions

(In %)

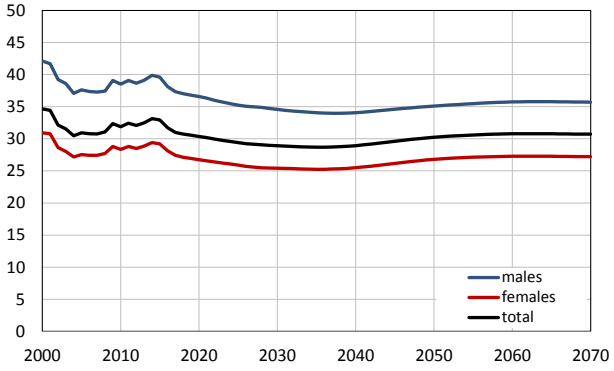


Figure 29: Old-age Pensions

(In %)

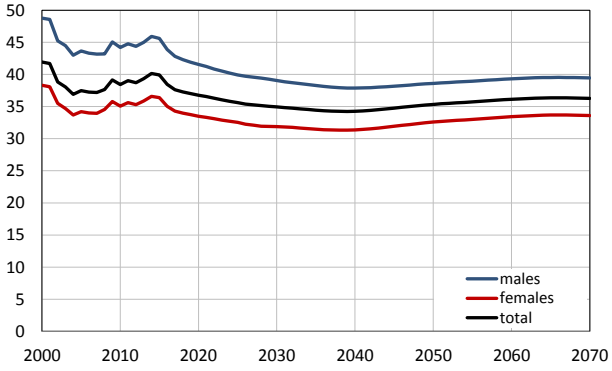


Figure 30: 3rd Degree Disability Pensions

(In %)

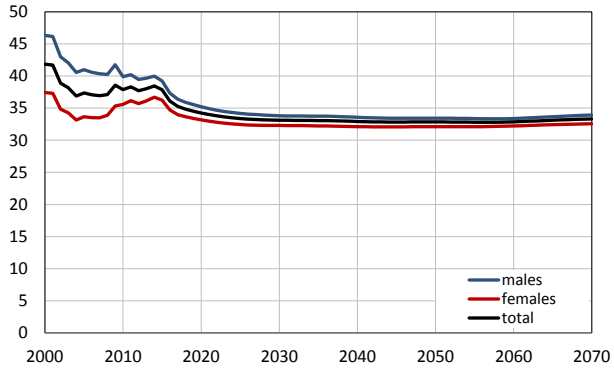


Figure 31: 2nd Degree Disability Pensions

(In %)

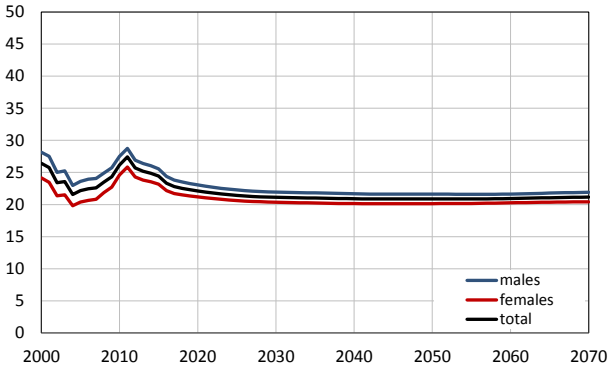


Figure 32: 1st Degree Disability Pensions

(In %)

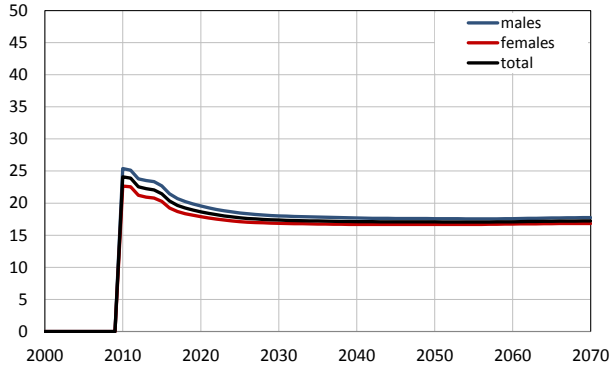


Figure 33: Widows'/Widowers' Pensions

(In %)

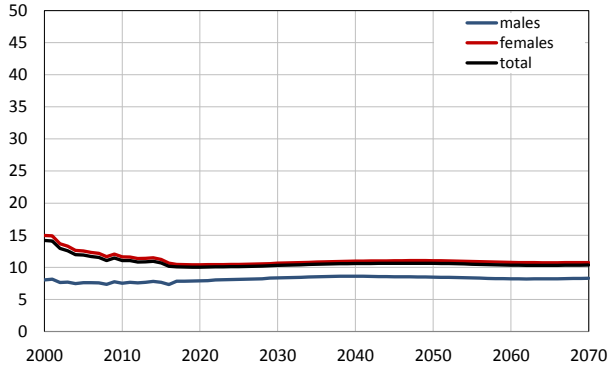
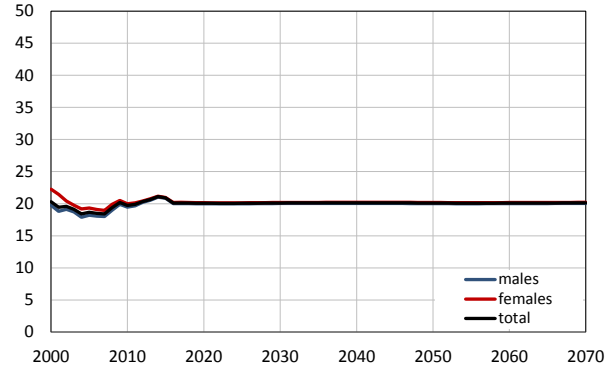


Figure 34: Orphans' Pensions

(In %)



Ministry of Finance of the Czech Republic
Letenska 15
118 10 Prague 1

http://www.mfcr.cz