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Pension Reform through Voluntary Opt-Out: The Czech Case*

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Abstract

The importance of long-term public finance sustainability in the context of current financial crisis is still seen as one of the basic factors of economic stability. Demographic development resulting in higher percentage of people in retirement age versus economically active people is one of the main risks. There is a growing pressure on expenditures of age-related systems. For this reason the pension scheme reforms are major issue in advanced countries. While some countries have chosen strictly regulated approach towards pension reform, some have given its citizens a choice whether to stay in the old system, or whether to switch to a new one. Such a decision is very complex and whenever the choice was implemented, many more workers switched to a new system than was expected.

In our paper, we present a micro-based simulation model for the Czech Republic that allows us to model the individuals' switching decision using several economic and behavioral factors within an old (PAYG DB) and new (FDC) systems. It allows us to estimate the proportion of people who would opt-out to a funded pillar.

Our results indicate that under the assumption of rationality and long run predictability of most parameters, only a small fraction of population would choose the multi-pillar scheme. However, this conclusion holds only under a full rationality. Once we relax this assumption, a wide range of switching strategies become viable. Therefore, the expectations that the switch will be popular cannot be based only on economic factors, but must also incorporate behavioral aspects, such as the risk of aversion.

1. Introduction

Public pension schemes in developed countries are among the most important existing redistributive programs. Their aim is to provide a long-term security of income for individuals in the situations when they are no longer gainfully employed. Due to the circumstances of their creation, the resulting systems were mostly based on pay-as-you-go (PAYG) scheme. It was administratively simpler and more transparent for an individual to base the pension system on the defined benefits (DB) design, where the final pension depends on the wage profile. Other retirement schemes were also created – a fully funded (FF) scheme based on the rule of defined contributions (DC), where the final pension depends on invested sum as well as on investment returns.

Extension of the social state in the second half of the 20th Century together with a steeply growing life expectancy and a shift in the existing demographic pattern led to the changes in originally small old-age pension plans into the most important expenditure item of public budgets. At the end of the 20th Century financing of these

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plans appeared to be unsustainable and the governments had to respond to the situation by introducing reforms. This process did not progress at the same pace. Not a single country proposed anything like "a universal model of the reform", which could (with minor modifications) be copied and transferred from one country to another.

Old-age pension system in the CR evolved in a manner similar to some developed countries. In the first half of the 20th Century a great variety of different schemes came into being (in the sense of setting redistribution rules) for different groups of persons (employees). Subsequently, under the Communist rule, they were extended and integrated into a single universal old-age pension scheme. Reforms which were to respond to the deteriorating demographic situation were launched only after the transformation of the centrally planned economy (CPE) to the market economy began (political economy of pension reform in the Czech Republic during the 90s can be found in Müller, 2002), whereas reforms in developed countries gradually started in the 80s (for detailed summary see Immergut, Anderson, Schulze, 2006).

One of the objectives of the Czech pension system reform in the last two decades has been to address the issue of long-term sustainability of the scheme. Government used to tackle this problem using mainly parametric modifications of the existing scheme. The 1966 reform attempted to stabilize the system's budget and to re-introduce the merit principle and diversification of funding. Klimentová (1998) discusses main changes in the Czech pension system until 1996.

Even while the reform in 1996 was being implemented, the demographic developments quickly rendered it insufficient. However, the more systemic reform which would enable a greater intervention in the existing system and generate alternative pension pillar schemes lacked a political consensus in the long run development of the pension system. A step towards consensus was the so-called Bezděk Commission in 2005 which was set up by the government to explore potential impacts of political parties' proposals of a systemic reform of the old-age pension scheme. The Commission (Bezděk et al., 2005:88) highlighted differences in the political parties' proposals, but it has not led to any further convergence in pension reform agenda and thus the Czech Republic still relies on a classical PAYG system with a negligible impact of funded (private and voluntary) pillar.

Our paper discusses effects of an hypothetical pension reform in the Czech Republic that would introduce the voluntary funded pillar and allow to opt-out from the existing purely PAYG and government run system. It is not our objective to discuss the necessity or risks of this pillar. Instead, we focus on the method used for people choosing to opt-out from the mandatory insurance. The focal point of our contribution lies in finding an answer to the question how many people will opt-out of the FDC pillar when they are allowed. Solving this problem can help in finding the suitable transformation method of the existing one-pillar system into a two-pillar one (the pillar of the voluntary supplementary pension insurance, called the third pillar is not discussed here). This problem had already been dealt with by Ježek in the Czech Republic (see Ježek, 2003), who compared the difference between replacement ratio (pension as a percentage of the preretirement wage) one can expect from the already existing PAYG DB system and replacement ratio one could get if they took part in FDC system. Our approach differs from the Ježek´s one mainly in

two aspects. First, we use updated estimates of main economic variables used in the model. Second, we attempt to evaluate the impact of irrational decision of an individual. This is not the case of neither our or Ježek´s model as our individual is strictly rational. However, our model tests the possible situation of repercussion, where the individual (for a number of reasons discussed below) does not behave rationally. The Ježek´s approach results (compared to ours) lead to the conclusion that switch is more beneficial for larger group of people. Some reasons for this difference are discussed in the Conclusion.

The first part of the article (Section 2) will indicate phases of the reform where opting- out could be incorporated and what factors influence an individual to opt-out. The following part (Section 3) formalizes the influence of the factors discussed in the previous part using a mathematical micro-simulation model. In the next part (Section 4) we perform sensitivity analysis which purpose is to demonstrate how individual's decision to opt-out changes according to the set of defined factors. Our results indicate that under the assumption of rationality and long run predictability of most parameters only a small fraction of population would choose the multi-pillar scheme. However, this conclusion holds only under a full rationality. Once we relax this assumption, a wide range of switching strategies become viable. Therefore, the expectations that the switch will be popular cannot be based on economic factors only, but must also incorporate behavioral aspects, such as the risk of aversion.

2. Pure Opt-Out and a Degree of Freedom of an Individual in Its Particular Areas

In 1975 the Great Britain was one of the first countries where people could choose to opt-out of the state-guaranteed pillar when they were not members of a contracted-out occupational scheme. In this situation they can join the FDC pillar administered by the private sector. Schulze and Moran (2006:60) say: "Employers had the possibility of contracting-out of SERPS, thereby receiving a rebate of the state pension contribution, if the occupational scheme they offered guaranteed benefits at least equal to the SERPS. "Two terms – *to contract-out* and *to opt-out* (and all its derivatives such as *contracting-out* or *opting-out*) – have been used in the similar context. We understand the term *to opt-out* in the same manner, i.e. the choice of an individual not to be involved, not to participate in something. *"Opting-out from the basic pension scheme"* is therefore further interpreted as a maximum freedom of an individual to decide whether to participate in the emerging second pillar. The opposite approach, in which a person has no choice to influence his/her part in the second pillar, is called the *state-controlled transformation*. The state controlled transformation means that the state takes away the option of personal choice and implements the approved form of the reform.

We argue that a real transformation (systemic reform) usually consists of several steps and the state has a possibility to provide an individual with a choice in some areas, while other areas are strictly controlled. The systemic reform than could provide the following areas where a varying degree of freedom could be applied: (1) freedom to join the FDC pillar, (2) the percentage of the opt-out rate, (3) the choice of a pension savings provider to accumulate pension assets, including a selection of the trade offs between gains and risks, (4) the choice when to retire and when to start drawing pen-

sion benefits from the FDC system, (5) the choice what to do with the pension assets upon retirement. Although the overall outline of the reform usually lies somewhere between the pure opt-out and state-controlled transformation, Palacios, Whitehouse (1998) showed that both pure opt-out and state-controlled transformation variants have been applied.[1]

Due to the spread of introducing the contribution based schemes into pension systems in the world, large volume of studies concerning the topic can be found. Most of them deal with the pros and cons (benefits and costs) of introducing such a scheme. (In the case of CR see e.g. Kreidl, 1998; Kubalčík, Zbořil, 2000, Bezděk, 2001 or Ježek, 2003). But as we stated before, the purpose of our article is different. We work with an assumption that the second pillar will be introduced in the CR (the decision has been made). The focal point of our contribution lies in finding a suitable method of how to transform the existing one-pillar system into a two-pillar one.

Similar approaches to ours are applied only for rather small part of the population. There are inspirational studies by Richard Disney and Carl Emmerson (Disney et al., 2001 or Emmerson, 2001) for the UK. Significant debate is devoted also to 401(k) program in the U.S.A. (see Miller et al., 2009). But most of these studies usually take the form of ex-post analysis of *who has opted-out* stemming from demographic principles. We argue that our approach is innovative in respect of ex ante analysis based on income, rather than on demographic principle.

3. Factors Affecting Jobholder's Opt-out

The individual's decision about opting-out can be simplified by comparing the loss of pension income that an individual will not be paid from the existing PAYG system with the pension income from the FDC pillar. We assume that individual *i* will opt-out if the following condition is satisfied:[2]

$$P^i_{PAYG} - \Delta P^i_{PAYG} + P^i_{FDC} \geq P^i_{PAYG} * RI^i$$

where P^i_{FDC} is the opted-out individual pension from the FDC system, ΔP^i_{PAYG} is the loss of pension from the existing PAYG in case of individual's opt out and RI^i we call the *rationality index*. Furthermore, we assume that the decision is made in particular year (2010 in our model) and only by individuals who are currently (in the year mentioned above) on the labor market.

The Section 3.1 presents micro simulation model of profit and loss of pension benefits from the subsequent pillars. In the following Section 3.2 we discuss the parameters which could be taken into account by an individual when evaluating the advantages of opting-out. Therefore our analysis could take two forms. First approach could be based on rational assessment of financial advantages of a new arrangement.

[1] They mention Argentina, Colombia or Peru as examples of pure opt-out variant and Bolivia, Kazakhstan or Mexico as examples of (pure) state transformation. For more comprehensive overview of current pension schemes in the OECD countries see OECD (2004).

[2] This model and the following ones are described in greater detail in the *Appendix*. Our model is similar to the one used by Disney, Palacios, Whitehouse (1999), who examine the welfare consequences of partial shift from a public unfunded scheme to a private scheme both from an individual and a macroeconomic perspective in the UK. The earlier analyses based on the same model of individual responses to privatization of the social security system in the USA can be found in Gustman, Steinmeier (1995).

But we argue that in reality people do not make a decision only on the basis of finite amount of financial parameters. Their decision making process might be more complex and may involve more inputs. Therefore we use a second approach where the rationality index is introduced to the model. The index suggests that individual may choose to opt-out even if that would result in (not a large) drop in his overall pension amount. Rationality index and overall influence of individual's (ir)rationality in the decision-making is further discussed in the Section 3.3.

3.1 The Model Assessing Advantages of Opting-out of the PAYG System

3.1.1 The Model of Pension from the FDC Pillar

To calculate the pension which an opted-out individual receives from the FDC system, some simple financial-mathematical relationships can be applied. Since the FDC model is characterized by full equivalence, it must be true that what is *saved* in the system is later *drawn* from the system in the form of pension benefits. For the sake of simplicity, we assume that an individual draws a life annuity from the FDC system. Based on the equivalence principle, an individual's pension equals:

$$P^i_{FDC} = f\left(W^i, cr_{FDC}, r, v, n_1, n_2\right)$$

where W^i is the gross wage during the saving phase, cr_{FDC} is the contribution rate to the FDC pillar, r the real appreciation rate of pension savings, v is the adjustment of paid out pension, n_1 is the length of gainful employment and n_2 is the life expectancy of the average individual of particular age cohort at the moment of retirement.

3.1.2 Loss of Pension from the PAYG Pillar

By opting-out the individual accepts the fact that his/her income from the pay--as-you-go system will drop. This drop (ΔP^i_{PAYG}) is given by the formula:

$$\Delta P^i_{PAYG} = P^i_{PAYG} * I^i_{OPT-OUT} = f\left(W^i, cr, r_h, rr, RA, ncp\right) \cdot f\left(n^i_{FDC}, n_1, cr_{FDC}, cr, \theta^i\right)$$

where P^i_{PAYG} is the original (non-opted-out) pension, $I^i_{OPT-OUT}$ is the share of opted--out pension from PAYG on total (potential) PAYG pension, r_h and rr are the reduction limits for calculating the percentage-based assessment, RA is the statutory retirement age and ncp characterizes the definition and method of inclusion of non--contributory periods. The symbol n^i_{FDC} denotes the saving period in FDC system of the individual, cr is the original rate paid to the PAYG and the coefficient θ characterizes the pension reduction from the PAYG system in case of opting-out.[3]

[8] In our model we assume that the reduction will be proportional to the extent of opting-out and will be uniform for everybody. It means that the coefficient θ is assumed to reach a unit value. Alternatively, we could suppose that the coefficient will (1) change in time, or (2) vary according to the individual's income, and (3) be different for a person during various stages of his/her lifespan. In this perspective our model does not involve any alternative scenarios. The system of accrued pension rights reduction is one part of switching conditions and should be decided politically. "Over restriction" might be the way to reduce transformation costs of the transition.

Parameters estimating the development of *labor productivity, inflation rate, number of employees and gross national product (GNP)* are crucial macroeconomic data and they appear practically in all models. Projected development of these parameters has been mainly taken from the Final Report of the Executive Team. As we expect that a different macroeconomic development will not significantly influence the decision-making about opting-out, we do not derive alternative macroeconomic framework.

Another significant parameter which is taken for granted without further discussion is the contribution rate (*cr*). The value of 21% (old-age pensions) has been used in our models instead of the total 28% current contribution rate (21% instead of 28% correspond to the fact that 73.5% of pension's expenditure in 2008 represented old age pensions, the rest belonged to disability, widow, widower and orphan pensions which are not matter of this article – similar concept can be found in Ježek, 2003:521). All other comparisons are related to the contribution rate which has been determined in this manner.

3.2 What Influences the Anticipated Pension from the PAYG DB and FDC Pillar

3.2.1 Level and Development of Wages (W^i)

The overall impact is examined for 200 model individuals who represent particular income percentiles (100 for men and 100 for women). For this reason it is also important to include projections of changes in income differentiation into the actual calculation of *wages of the individual* W^i in a given income percentile.[4] Pensions from the FDC pillar are affected by the earnings during the whole gainful employment, while in the DB pillar the earnings taken during the relevant period (last 30 years) are decisive. That is why income differentiation may influence the level of pension from both systems. In our model we expect the income differentiation measured by the decile ratio of wages to be at the level 3.5 in the year 2050.[5] According to OECD (2009a) statistics the indicator falls between 3.0 and 4.0 in vast majority of countries, with some countries reaching the level of 5.0 (Hungary, USA) and in some countries, on the other hand, the level of 2.0 (Belgium, Sweden, Finland, Denmark). The model sensitivity analysis did not reveal any major influence of the income differentiation development. That is why this analysis was not discussed in the follow--up text any longer. Although, this does not affect the fact that wage differentiation development may influence the further evolution of PAYG DB system. The patterns modeling the wage development together with the wage projection until the year 2050 can be found in the *Appendix*. Furthermore, it is assumed that a person's income moves around a certain unchanged income level (appropriate income percentile) through the whole career. Average wage growth is taken from the data provided by the Team of Experts. The data are based on assumed wage growth in EU countries together with the speed of convergence of the Czech economy with the EU countries.

[4] Source is a publication of the Czech Statistical Office about wage differentiation in 2008 (CSO, 2009) and also the data acquired from our models.

[5] This means that in 2050 the wage of the ninth income decile is 3.5 times higher than the wage of the first decile.

3.2.2 Opt-out Contribution Rate in the FDC Model (cr^{FDC})

The level of contribution rate in the FDC system naturally determines the extent of opting-out. It can be generally assumed that the level of this rate may vary in the course of the working career and so cr^{FDC} represents a vector of rates rather than a single concrete value. The model enables us to express the advantages of opting-out for a contribution rate variant. Concrete values of opt-out percentage are essentially influenced by the macroeconomic framework of the reform. It can be assumed that opting-out is largely determined by the ability of the state or public finances to cover the cost of such changes. Kreidl (1998:39) assumed present value of the implicit pension debt[6] for the statutory pension age 65 between 180 and 230% GDP. Later IPD calculations (see MLSA, 2004:91, Bezděk et al., 2005:17 or MLSA, 2008:70) have decreased its level towards 70–120% of GDP. Introduction of FDC pillar will induce transformation of the IPD into explicit debt. It is hard to say what the extent of such transformation will be, as it is influenced by the set condition of such switch. One can say that one of the most important factors are: the opt-out contribution rate, number of people who opted-out to FDC or system of reduction of pension rights from PAYD DB. In our article we set the opt-out contribution rate at 6%, since we believe that such transformation would not pose serious problems with financing the transformation costs of transition.

3.2.3 Estimated Return on the Pension Portfolio and Its Volatility (r)

Generally, a higher appreciation of assets in the FDC pillar will lead to a higher extent of opting-out. The crucial question is what will be the real appreciation of assets in the FDC. Can we apply historical experience to its estimate?

According to the study of the London Business School (cited from ABM AMRO, 2007:5) the *average annual return* for the global stock markets during the past 100 years (including reinvested dividends) was about 5.8%, 1.6% for bonds and only 1% for public securities. Capital markets are characterized by a *considerable volatility*. The above mentioned study (ABM AMRO, 2007:7) claims that volatility reduction, which may be reached by a convenient structuring of the portfolio, results in a drop in its average return. The latest London Business School study admitted the fall in the real return on the global index for equities to 5.2% caused by the fall in capital markets in the years 2007 and 2008 (Dimson, Marsch, Staunton, 2009:43). However, it has attracted attention to the fact that the main part of the aver-age return is being generated from reinvested dividends, capital appreciation is of lower importance.

The European Commission represented by the *Economic Policy Committee (EPC) agreed that a long-term real rate of return of 3%* will be assumed for calculations of impacts of population ageing (EPC and EC, 2005). Their sensitivity tests of models worked with alternative rates of 2% or 4%.

We consider the possibility that an individual can save money in three various funds in his/her lifetime.[7] We have dubbed them *Growth*, *Balanced*, and *Conservative*. The Growth fund will have the highest average return but it is linked with

[6] Definition of IPD and its measurement is not the subject of this article and can be found e.g. in Holzmann, Palacios, Zviniene (2004)

[7] The idea is based on the current state of the Slovak pension system.

Table 1 Projected Real Appreciation Rates in the FDC Model

	Accumulation of assets – fund type			Rate of return during annuity drawing
	growth	balanced	conservative	
	(max. 15 years before retirement)	15 to 7 years before retirement	7 years before retirement	
Basic variant	4.5%	3.2%	2%	2%
Variant with higher return rates	5.5%	4.2%	3%	3%
Variant with lower return rate	3.5%	2.2%	1%	1%

Source: Authors.

a higher volatility. To decrease it, the individual has to transfer his pension assets into a fund with lower volatility (balanced or conservative) at certain point prior to retiring. These funds generate a lower rate of return. We test the individual's sensitivity to changing volatility by means of variants with different level of profitability.

We treat the administrative costs (annual charges) of pension saving providers as asset-based and we set the level at 1% of the assets value annually.[8] The impact of different *average rate of return r* on the choice of opting-out is evaluated by using the sensitivity analysis. We will suppose that pension savings providers will achieve either higher or lower rate of return on pension assets. Projected values of the alternatives are summarized in the *Table 1* together with the values of the basic variant.

3.2.4 Adjustment (Valorization) of Paid-out Pension Benefits (v)

In a consistently equivalent FDC model the method of adjustment of paid out annuities does not play any role. The retiree will get back his/her assets at the same level; what will change is the distribution of assets in time. Let us suppose that paid out pensions from both systems are adjusted according to the same rules. Since the rule of FDC pension adjustment cannot influence the net present value of pensions paid in future, we can employ the adjustment rule from the PAYG DB pensions even for FDC pensions. We do so to compare the FDC pension with the loss of pension in PAYG DB. The same method was applied by Ježek (2003:518). (See formula (9) and (10) in *Appendices*).

3.2.5 Duration of the Saving/Insurance Period (n_1) and Non-contributory Periods within Saving/Insurance Period (ncp)

When projecting the duration of saving period (FDC) or insurance period (PAYG DB), it is vital to estimate non-contributory insurance periods (e.g. duration of study, unemployment, childcare or sickness). *Non-contributory periods of insurance* affect the calculation of particular pension benefits both in the PAYG DB and

[8] Many kinds of charges can be applied by pension funds. These charges differ across the countries and pension funds. Whitehouse (2000:13, 28) uses *charge ratio* for overall impact of charges on pension savings. For selected Latin America countries he found that the charge ratio lies between 13.5 and 26%. In our model the value of the charge ratio equals 18.3% (for the individual 40 years before retirement).

For measurement of overall impact on the level of annuity we can use Money worth ratio (MWR). According to James, Vittas (2000:26) MWR is mostly between 0.8 and 0.95. For CR Ježek (2003:521) uses MWR = 0.90. In our model the value of the MWR equals 0.895 (for the male who has just retired).

Table 2 Influence of Non-Contributory Periods (*ncp*) in the PAYG DB System

	Duration of insurance in years		
	men	women	unisex
Average insurance period	44.4	39.6	41.6
Insurance period without *ncp*	36.1	30.7	33.0
Share of *ncp* on average insurance period	18.7%	22.5%	20.7%

Source: Holub (2009:486)

the FDC system. While *ncp* is considered as an insurance period within PAYG DB, FDC model does not compensate for it. Non-contributory periods in the Czech pension system have been examined by Holub, 2009. Conclusions from his research are summarized in the *Table 2*.

According to the *Table 2* above, the average length of insurance lies between 30.7 years (women without *ncp*) and 44.4 years (men with all *ncp*). The future duration of insurance will be influenced by: (1) advancement of the retirement age (+), (2) increase in the length of education (-), (3) increase in impact of unemployment periods which did not have any significance prior to 1989 (-), (4) gradual elimination of generous ncp recognition in existing PAYG DB system (-). Unfortunately, we are not able to precisely qualify the parallel influence of the above mentioned factors on the total insurance (PAYG) or saving duration (FDC). Therefore, in our models we count on constant length of the saving period (40 years) which is considered in both the PAYG DB and in the FDC models and which is identical for both men and women. Further on we suppose that the non-contributory period proportion throughout the gainful employment will be on average 10%, both for men and women.

Alternatively we are going to test the FDC model for the impact of shorter (*ncp* = 0% both for men and women) or longer (*ncp* = 20% both for men and women) non-contributory periods, which can be interpreted in several ways: (1) the impact of raising the retirement age, (2) the impact of changing the approach towards non--contributory periods in the PAYG DB pillar, (3) the impact of taking into account the non-contributory period in the FDC pillar if the state chooses to pay the contributions to the FDC pillar in certain cases, (4) the impact of not considering childcare periods as insurance period.

3.2.6 Duration of the Payout Annuity (n_2) and Retirement Age (*RA*)

Duration of the payout annuity is equal to life expectancy (LE) upon retirement and in this respect crucially depends on precise retirement age (*RA*). Factor (*RA*) appears in two forms in both models. The retirement age is stipulated by the law and our models work primarily with 65 years. Where possible and appropriate we have also made estimates for 67 years.

However, LE depends more on the real retirement age rather than on the statutory retirement age. On average people retire before they reach the statutory RA. Based on the existing development we have included an arbitrary projection of deviation from the statutory and real retirement age. In 2007 it was equal to 1.2 years for men and 1.33 years for women. Similar difference can be observed in other years as well. For the sake of simplicity the parameter has been fixed at 1 year. A potential development of LE in the CR is indicated in the *Table 3*.

Table 3 Potential Development of Life Expectancy at the Age 65 in the CR

Year	Source of data	MALES	FEMALES	UNISEX
2006	CSO	14.79	18.01	16.54
2050	EPC and EC	19.70	23.00	21.50
2065A	Bezděk	21.58	24.90	23.29
2051B	Bezděk	27.92	30.14	28.98

Notes:(1) UNISEX data are calculated as weighted arithmetic mean (where available) for males and females.
(2) 2065A – calculated as "current life tables" for the year 2065.
(3) 2051B – calculated as "generation life tables" for persons born in 2051.

Source: CSO (2007); EPC and EC (2008); Bezděk et al. (2005).

According to the Czech Statistical Office (CSO, 2007) the life expectancy in 2006 for 65 year-old males was 14.8 years, and for females 18 years. According to the recent development in European countries it can be said that the LE of 65 year--old persons increases every decade by one year (see OECD, 2009b). At the moment nothing seems to suggest that this trend could change and that the LE will not increase by further 4–5 years in the coming 50 years.[9]

Our projections of the LE are based on the life tables of the Czech Statistical Office (CSO, 2007). We assume that the LE of a 65 year-old person increases by 0.1 year every year. Using this rule the LE of a 65 year-old person, regardless of sex, will be 20.8 years in 2050, which is 0.7 year less than EPC and EC (2008) projection. The LE of a 65 year old-person is 22.3 years for the year 2065, which is a year less than corresponding demographic projection by Burcin, Kučera (2004).

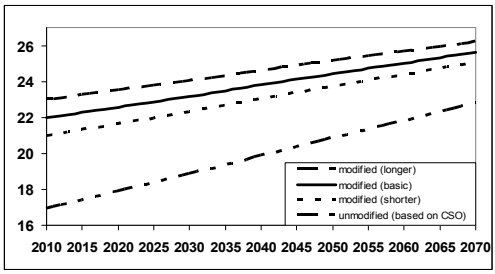
To test the sensitivity in case of opting-out, we have used other two variants of life expectancy. The *longer variant* prolongs the LE, while the *shorter variant* shortens it. Departure of both variants from the base projection will be 0.7 year in 2050. The same concept was used by the EPC and EC (2008) which tested a variant of increased life expectancy at birth by one year by 2060 compared to the baseline projection. In our model instead of using sex-specific life expectancies we use unisex life expectancy as such practice better reflects the shape of newly launched capitalizing pillars in EU (e.g. Hungary, Poland or Slovak Republic – for basic description of their pension systems see OECD, 2009c). Individually applied variants of LE are graphically represented in the *Figure 1*, full figures are presented in the *Appendix* on the journal web page.

3.2.7 System of the Income Redistribution in Paid Out Pensions (*rh, rr*)

Pension systems play important re-distributive role as well. The redistributive function of the Czech system is captured by three factors – the basic income level, which is uniform for all pensioners, and two reductions limits that influence income--related part of the pension. We assume that adjustment of three basic parameters allows us to model future income redistribution within the first pillar. The basic variant assumes that the current level of the basic amount, the first and the second reduction limits are fully adjusted according to the inflation rate and partially (75%)

[9] Life insurance companies base their calculations of life annuities on a conversion of current (cross-sectional) life tables into generation (cohort) tables, which increases the life expectancy by about 5 years (Bezděk et.al., 2005).

Figure 1 Unisex Projections of Life Expectancy at the Age of 65 Using Correction Coefficients



Source: CSO (2007); own modification.

Table 4 Provision for a Growth in Real Wage in Indexation of Parameters in the First Pillar [a]

	Basic amount of pension	First reduction	Second reduction
Basic variant	75%	75%	75%
Redistributive variant	140%	60%	0%
Differentiation variant	0%	75%	150%

Note: [a] Particular variants lead in the long run (2050) to similar replacement ratio of average wage earner. Variants mainly differ in change of the equivalency between contributions and benefits. While the Redistributive variant decreases income differences among individual pensions, the Differentiation variant does the opposite.

Source: Authors.

according to an increase in real wages. Together with this variant, two additional variants are tested. One of them is called *Redistributive*, in which the present redistribution role of pensions is strengthened. *Differentiation variant* allows for a gradual weakening of income redistribution. Projections of the adjustment method are summarized in the *Table 4*.

3.3 Behavioral Factors that Influence the Decision of an Individual to Opt-out

In addition to the above mentioned factors – which are relatively easy to quantify – a host of other factors will influence an individual in his/her decision-making about opting-out. Some of them are related to the above mentioned, others are qualitative (behavioral) and so they are difficult to quantify. The following section describes some of the most relevant factors.

When assessing the advantages of opting-out we rely on the rationality of an individual. Thaler, Benartzi (2004) argue that we should consider individuals bounded as rational. The problem solution is a *hard one even for an economist* and individuals may not be able to evaluate the entire range of aspects influencing opt--out. There are a number of behavioural factors that can influence opt-out decision, the most decisive are:

– Individual's preferences regarding diversification of the pension portfolio. A decision of an individual to opt-out will be also affected by his/her personal preferences for the diversification of the pension portfolio. It can be characterized as *positive insurance benefits from diversification* (Brugavini, Disney, 1995). On

the other hand, these benefits may not offset the transaction costs of entry to the private schemes (Disney et al., 2001). With regard to the outlook of the Czech pension system it can be expected that individuals with a higher income will tend to diversify.

– Lack of or inaccuracy of available information due to an insufficient or inaccurate presentation from the government, deceptive (misleading) campaigns of opposing political parties, or the influence of influential interest groups (such as promotion of pension savings providers).
– Risk aversion. Persons with a strong risk aversion can choose to remain in the first pillar, because they think that the FDC pillar is too risky. Risk aversion can be higher in older persons who approach the retirement age (they distrust private pension saving providers due to recent experiences). On the other hand, Dusek, Kopecsni (2008) show that inherent riskiness of often-reformed public PAYG systems is comparable to risks associated with private systems.
– Influence *of leading members of the community* on the decision of an individual. (Demonstration or hallo effects when a person imitates the decision of others who are in a different income bracket or belong to a different age group. Sometimes there is a trend towards *family decisions*, if the household head decides for all household members.

All these influences can result in considerable differences between the final number of opted-out persons and our presented estimates.[10] Thanks to their certain contradictory character, it is not possible to accurately predict their overall effect. As we stated above, we have introduced these factors into our model as *Rationality index* (*RI*). For the purpose of subsequent sensitivity analysis we use three basic values of *RI*. The basic variant presumes no other than pure financial (or rational) factors and $RI = 1$. But individuals could be motivated to opt-out even when their gain from FDC pillar is less than the loss from PAYG. For that case we use $RI = 0.95$ (we call such variant "a low risk aversion"). On the other hand, Palacios, Whitehouse (1998) argue that for people (especially low-income workers) the future (small) gain from switching to FDC would not overcome the cost of the decision (information cost, charges and risk). For that variant we use $RI = 1.05$ (we call such variant "a high risk aversion").

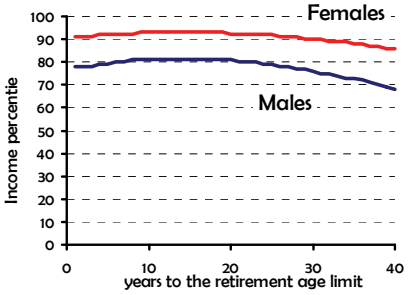
4. Results of Opt-out Simulation

In the previous section we have identified the series of variables used in our models. This section is dedicated to the results of modeling the advantages of opting--out.[11] First the basic alternative is modeled, based on the above mentioned assumptions about values and development of individual parameters. The remaining section specifies the outcomes of values assumed by particular parameters. We should stress that sensitivity of the opt-out advantages to a change in (setting) these parameters is considered more significant than any concrete values (advantages for given groups of persons). The basic variant of parameters setting is summarized in the *Table 5*.

[10] The assumption is confirmed by the case of Slovakia, where many more persons decided to opt out than estimated. Potential consequence can be a recent reopening of the second pillar, which represents a marked change of the proposed system.

[11] The detailed presentation of results is available on the journal web page.

Figure 2 For Which Income Percentile It Is Advantageous to Opt-Out (basic variant)



Source: Authors.

Table 5 Basic Variant of Assumption about Further Development of Significant Parameters

	Phase of pension assets creation – fund type			Phase of pension assets withdrawal
1 Real return rate (in %, after deducting administrative costs)	growth	balanced	Conservative	
	3.5	2.2	1.0	1.0
2 Development of unisex life expectancy at 65 years	2020	2030	2040	2050
	22.6	23.2	23.8	24.4
3 Share of non-contributory periods in FDC (from the total of 40 years of gainful employment)	Males		Females	
	10%		10%	
4 FDC contribution rate (opted out of PAYG DB)	6%			
5 Allowance for the growth in real wage for indexing some parameters in the first pillar	Basic amount of pension		First reduction	Second reduction
	75%		75%	75%

Source: Authors.

Although there are several possibilities how to analyze the influence of above factors, we present our results using one graph. For more detailed analysis we refer to *figures* and *tables* in *Appendix*, additional information is available from the corresponding authors upon request. The presented *Figure 2* shows for which income percentile it is advantageous to opt-out, depending on the number of years remaining to the retirement age limit. Advantages are shown separately for males and females.

As seen from the *Figure 2* and *Table 6*, under basic setting opting-out is advantageous only for a relatively small group of persons. It is only applicable to men and especially to women in the highest income percentiles. The figure shape suggests that the advantages of opt-out for individual percentiles vary according to the number of years before retirement. However this dependence is not linear. The number of persons for whom it is advantageous to opt-out drops first. With the increasing time period of a person to the retirement age it starts to grow.[12] It is understandable that a maximum number of people for whom the opt-out is cost-effective is found in the youngest age bracket.

[12] It is manifested by the fact that the first income percentile for which it is advantageous to opt-out is decreasing.

Table 6 Growth (+) and Drop (-) in the Gross Replacement Rate of the Opted-Out Pension in Comparison with the Non-Opted-Out Pension for Some Income Percentiles [% of the pre-retirement wage]

W^i	Males				Females			
	2020	2030	2040	2050	2020	2030	2040	2050
W^{10}	-1.9	-3.8	-5.2	-6.1	-2.8	-5.5	-7.7	-9.3
W^{25}	-1.3	-2.5	-3.4	-3.8	-2.0	-3.9	-5.3	-6.2
W^{50}	-0.8	-1.5	-1.8	-1.5	-1.2	-2.4	-3.2	-3.5
W^{75}	-0.1	-0.2	0.0	0.8	-0.7	-1.3	-1.4	-1.1
W^{90}	0.4	0.9	1.6	2.7	-0.1	-0.1	0.2	1.0

Source: Authors.

Among main reasons which determine such shape can be found:

(1) The convergence of the Czech economy to the EU countries results in a faster wage growth in the first years of the modeled period (real growth of average wage in 2015 is 2.8%, contrary to 2.1% in 2050). This causes higher IRR of the PAYG DB pillar compared to FDC and subsequently results in the constant (or slightly decreasing) number of individuals who would opt-out. The influence of the convergence is substantial mainly with individuals who switch 1 to 15 years before retirement. With the period closer to the year 2050 this argument is fading.

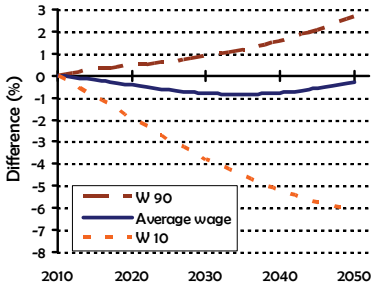
(2) The lower real rate of return (FDC) makes the "opt-out curve" rather flatter for people who switched a few years before their retirement. The advantage of long term savings belongs only to young and middle age generation.

(3) Growing life expectancy lowers pensions from the FDC pillar. This fact does not envisage direct influence of the pension from PAYG DB model. However, in reality this might be one of the main factors in the long run. Such argument may explain why the "opt out curve" declines quite gently for people switching 30 to 40 years before their retirement.

Similar shape of the "opt-out curve" for countries which introduced FDC pillar can be found in Palacios, Whitehouse (1998). While our "opt-out curve" predicts the number of individuals who would opt-out, Palacios and Whitehouse present real shares of opted-out individuals in total.

To show the influence of the factors, we perform the sensitivity analysis. In the following section we present the results only for the parameters which have a remarkable impact on the opt-out rate. Other graphs showing various aspects of opting-out can be found in the *Appendix*. The most interesting is the difference in the *total replacement ratio* for the males according to time to retirement (total opted--out pensions minus non-opted-out pension). The *Figure 3* compares the two replacement rates and the results are presented separately for three wage levels. This graph might be seen as a comparison of the reform scenario with the no-reform scenario. But the reader should be aware of the fact that results for the no-reform strategy are only approximate, as we are not able to anticipate the (political) setting of the PAYG DB pillar in the long run. The figure logically complements the presented figure showing the (dis)advantage rate of opting-out for selected income percentiles. If opting-out is mandatory for all, this figure illustrates varying income distribution of pension benefits in connection with the opt-out.

Figure 3 Difference in the Total Replacement Ratio for Males According to Time to Retirement



Source: Authors.

4.1 Sensitivity of Results in the Basic Variant of Parameters to a Gradual Change in the Following Parameters

4.1.1 Real Rate of Return

If the estimated rate of return grows as compared to the basic variant, (by 1% in all phases) the number of persons for whom the opt-out is advantageous grows slightly. The proportion certainly increases in time (it means that the opt-out is best for the young who will retire in 30 or more years).

By contrast a decreasing rate of return (by 1% against the basic variant), which corresponds to the *variant with a lower rate of return of assets* (see *Table 1*) leads to a situation where a number of opted-out persons is negligible. Thus it can be concluded that with a declining assets appreciation, the number of opted-out persons decreases significantly (see *Figure 4*).

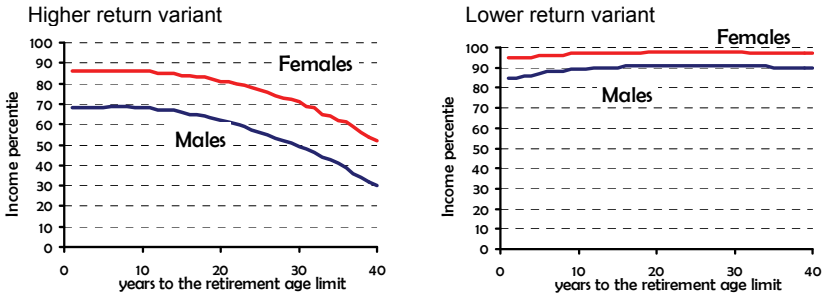
4.1.2 Life Expectancy

Regarding the life expectancy we ran the sensitivity tests only for FDC pillar (PAYG DB pillar being fixed). The impact of life expectancy on the proportion of opt-outs is then unambiguous – the shorter the life expectancy at 65, the more jobholders will opt-out from the first pillar. The effect of this parameter is prominent: the number of persons who opt-out grows by 5% for each year by which the life expectancy is lower. Similar principle applies when the life expectancy increases. Due to the fact that changes in the life expectancy influence PAYG DB pension also, we can conclude that impact of this factor is rather minor (see *Figure 5*).

4.1.3 Duration of Non-contributory Periods in the FDC

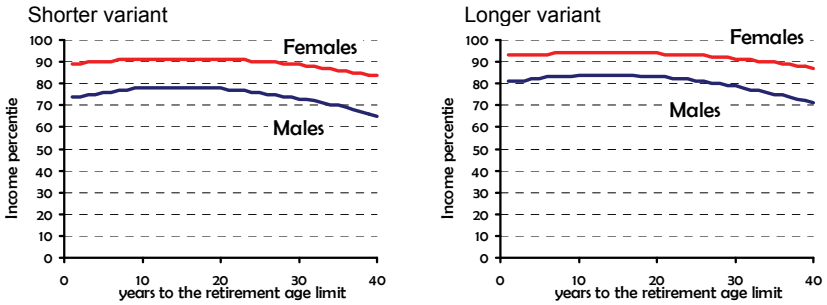
Extension of the period of inactivity results in the drop of the number of people who would opt-out (for detailed results see *Figure 6*). If we suppose that women will be inactive for the period of 20% (instead of 10 % in the basic variant) of their working life, the opt-out becomes disadvantageous. If we suppose that a jobholder has no period of inactivity in the course of his/her working life, the advantage of opt--out will be more prominent (especially for males – opt-out is advantageous for almost of half of them). The rules for inactivity periods are set by the state and they directly influence the advantage of opt-out for people who are at or slightly above the average wage. Indirect reduction of non-contributory period can be regarded as

Figure 4 Opt-Out Rate in Men and Women with Differing Appreciation Rate



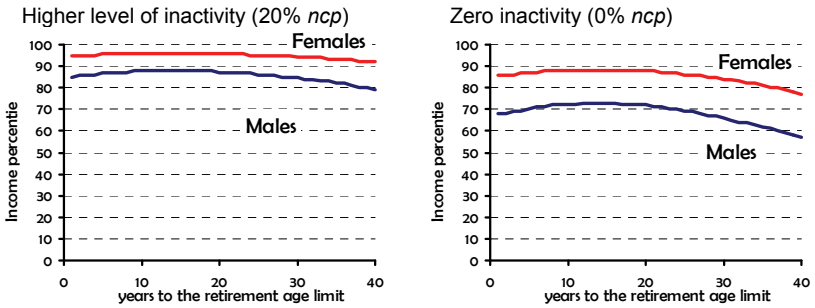
Source: Authors.

Figure 5 Opt-Out Rate in Men and Women for Different Life Expectancies



Source: Authors.

Figure 6 Opt-Out Rate of Men and Women in Case of Different Non-Contributory Periods



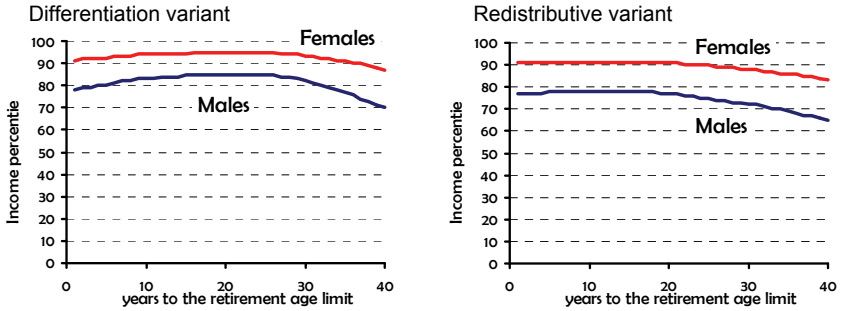
Source: Authors.

prolonging statutory pension age – an individual has to work longer with the same PAYG DB pension and increases FDC pension.

4.1.4 Effects of the Real Wage Growth in Indexation of Some Parameters of the First Pillar

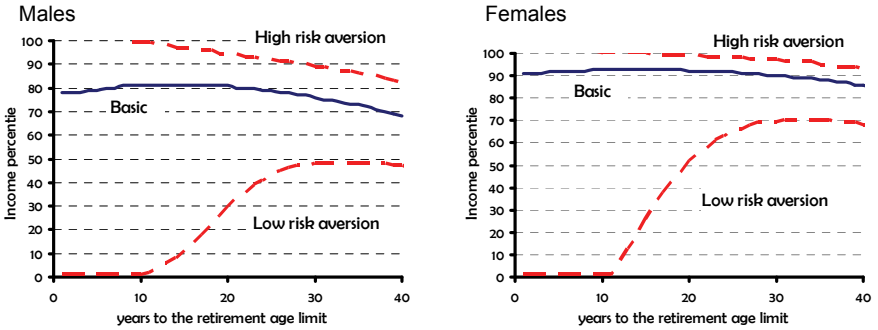
First pillar setting and parameter indexation (see *Table 4*) play an important role for the degree of opting-out in various groups of persons. If the first pillar was

Figure 7 Proportion of Opted Out Males and Females for a Various Setting of the First Pillar



Source: Authors.

Figure 8 Proportion of Opted-out Males and Females for a Various Setting of the Rationality Index



Source: Authors.

markedly redistributive, the number of persons who opt-out would increase. This growth would be accompanied by a slight drop in the replacement ratio as well as by a lesser degree of pension distribution (see *Figure 7*). On the contrary, a low degree of pension redistribution in the first pillar would not change the proportion of opted--out persons very much (in comparison with the basic variant).

4.1.5 Sensitivity to Individual Rationality

Individual rationality seems to be the most important factor which influences the number of opted-out persons (for detailed results see *Figure 8*). We have set the level of rationality index (*RI*) to 0.95 and 1.05 respectively. This setting is rather arbitrary. In our view the width span of RI is quite narrow for persons below the age of 50. (We might mention that the probability that a person at the age of 60 dies before reaching retirement age is higher than 5%). This might be supported by the fact that no one can predict the level of pension from PAYG DB in the 15 year horizon. Narrowing interval for the two levels of *RI* is influenced by the way we have applied *RI* in the model. If we used *RI* only for the fractional pension which resulted from the opt--out, it would make the interval narrow even for the persons who are just before their retirement age. High sensitivity to *RI* factor can give a partial answer to the ques-

tion why more Slovaks opted-out than it had been predicted by model calculations (MPSVR SR, 2007).

It may be rather surprising that the variant „low risk aversion" is increasing the number of the opted-outs up to 100% in case of age cohorts switching just before their retirement. As a result of later retirement age, in case of switching, the number of individuals willing to opt-out is decreasing. This is a consequence of the fact that the rationality index is applicable to the total amount of PAYG DB pension. It may lead to a situation that the individual who is switching a couple of years before the retirement is facing the lower loss of PAYG DB than corresponds to 5% *RI* influence. In such case the individual always opts-out, ignoring the impact of other parameters. The test could be modified as to compare only potential losses from the PAYG system and potential gains from the FDC system in the case of opt-out. If this is the case, the "risk aversion" curves in the *Figure 8* would converge more closely to the basic variant opt-out schedule. However, we believe that individual choice would be based more on comparing the *total* value of pension, not incremental losses and gains even though it may lead to paradoxical results for individuals few years before their retirement.[13]

5. Conclusions

Experience from the countries which have carried out the pension system reform shows that the decision about the form of pension system is primarily political. When analyzing expectations of pension scheme expenditure in 17 OECD countries, Schneider points out that the influence of economic factors on occurrence of pension reforms is unconvincing. He follows "*that governments do react to expectations of increasing pension expenditures, but they are unmoved by the level of* [current] *pension expenditures*" (Schneider, 2009:305). In our article we start from a simple proposition that the decision about the move toward the capital pillar in the Czech Republic has been done. Our objective then was to formulate the way how to carry out the transformation. We differentiated between the *opt-out form,* when individual can decide whether and how to participate in the reform, and the *form of state controlled transformation,* when all decisions on the shape of transformation are given by the state on behalf of an individual.

Our paper then focused on the issue of the proportion of the Czech population who will decide to opt-out from PAYG DB to FDC when they are allowed. Our analysis is based on micro-simulation model in which we compare pension of the individual whose pension is opted-out with the pension of the same individual in case (s)he stays only in the PAYG DB pension pillar. In the year 2010 only around 20% to 30% of men with highest salaries (resp. 8% to 12% for women) would opt-out to a multi-pillar scheme. This result is valid only under the assumption of rationality and long run predictability of most parameters. Our results are consistent with the calculations made by Bezděk Commission which claimed that approximately 50% of men and less than 10% of women will opt-out (see Bezděk et al., 2005:23 and 37).

[13] For example, worker on the 20th percentil and 5 years prior retirement would lose by 50% more in the PAYG than he/she would gain in the FDC system. Therefore, when comparing gains and losses, he/she would probably never consider opting-out. However, his/her pension would fall after opt-out by 1.3% only: a loss he/she can easily choose to ignore.

The sensitivity analysis showed that the rate of real return of the pension assets is the most influential parameter. Higher appreciation rate make opt-out more favorable for more than 70% of the men and almost 50% of the women who are entering labor market. Similar analysis for the Czech Republic was made by Ježek (2003). His results do not clearly show the number of people who would opt-out, as the outcome of his model is the so-called switching wage. It states from which wage level it would be profitable for an individual to opt-out in the year 2005. In all analyzed variants he shows that the level of switching wage is lower than the basic variant in our model. Our model shows similar results only when the variant where the pension funds realize higher real rate of return of pension actives is applied. This example implies that the difference between Ježek´s and our results is mainly given by the set-up of parameters. Relaxing the condition that the individual's decision is done only under strict rational arguments induces that opt-out might be favorable for significantly larger proportion of the population. Therefore, based on full rationality we suppose that number of people who will opt-out will be higher than predicted by Bezděk Commission or by our calculation.

We believe that our estimates are supported by the Slovak Republic's experience. Their first calculations underestimated the real number of people who have opted-out. We argue that such *irrational* behavior can be explained by two arguments: (1) in case when long run financial sustainability of the first pillar (PAYG DB) is unpredictable or unwarrantable, it might be wise for everybody to diversify the future pension, (2) individual thinks of pension savings as personal assets which may be inherited, whereas future pension from PAYG DB might be rather uncertain.[14] The question is whether it is possible to implement such behavioral factors into mathematical model.

We should also ask what the consequences of an individual's *irrational* decision might be in the reform as far as the opt-out is concerned. The more persons opt-out, the higher share of implicit pension debt is transformed into explicit debt. This might cause problems in a public debt management. To what extent are these problems crucial so that the concept of transformation using opt-out can be refused? The vital factor for this decision is the level of the opt-out insurance rate, because higher insurance rates will enlarge the problems and vice versa. Even if the problem of transformation costs has been put aside in our analysis, we believe that the realization of the way of transformation we are suggesting would not cause serious problems to the Czech public finance, not even in the situation in which a larger number of people than estimated in the model would opt-out. Moreover, the model showed the fact that potential decrease in pensions by some individuals is not of such extent which would make the state solve the outcomes by some systemic measures.

A more rigid (controlled) transformation, with no voluntary opt-out and with strict age limits for switch to the new system – along the lines of reforms in Poland or Chile – might decrease uncertainty during the reform and might limit the scope for irrational decision by individuals. However, the government is able to limit uncertainty and irrationality only if it can correctly predict developments of main economic and

[14] This argument might be supported by Dušek, Kopecsni (2008:342) who proved that the policy risk of the PAYG system in three central European countries (Hungary, Slovakia and the Czech Republic) *can be substantial*.

demographic parameters and then commit itself to a consistent reform policy over a longer term. The recent Czech experience warns that these conditions for consistent government policies might be too strict. If so, we cannot claim that the controlled transformation is more appropriate than the opt-out version. In such case it is impossible to predict the reform strategy which would lead to a more efficient outcome.

APPENDIX

Models Used in Our Analysis

1. PAYG DB Model

Calculation of the new acknowledged pension is done by using the current practice in the CR (according to Section 33–36 of the Act No. 155/1995, Coll.). The equations (1)–(5) also uses Bezděk (2005), the *philosophy of the calculation can be found in MLSA* (2008:94–96).

$$P^i_{PAYG} = BA + PA^i \tag{1}$$

$$PA^i = n^i_1 * ar * CB^i \tag{2}$$

$$CB^i = \left\{ PAB^i * rr_1 - \max(0, PAB^i - rh_1) * (rr_1 - rr_2) - \max(0, PAB^i - rh_2) * (rr_2 - rr_3) \right\} \tag{3}$$

$$PAB^i = \frac{\sum_{k=Y-1-\min(30,Y-1-1986)}^{Y-1} AB^i_k * \prod_{j=k}^{Y-1} w_j}{\min(30, Y-1-1986)*12}, \quad w_j = \frac{\overline{W_{j+1}}}{\overline{W_j}} \tag{4}$$

$$PAB^i \approx \frac{AB^i_{Y-1}}{12} = W^i_{Y-1} \tag{5}$$

(1) Pension is composed of two elements (a dual component structure):

BA – basic amount (flat rate) and

PA^i – a percentage-based assessment based on the insured period and earnings achieved.

(2) The amount of PA depends on personal insurance period ($n^i_1 = 40$), "entitlement" ($ar = 1{,}5\%$) and personal calculation base (CB^i).

(3) Personal calculation base is given by personal assessment base and reduction limits ($rr_1, rr_2, rr_3, rh_1, rh_2$).

(4) Personal assessment base depends on annual bases (AB^i_k) within the reference period; annual bases are adjusted by the coefficient of the growth of the general assessment base ($\prod_{j=k}^{Y-1} w_j$).

(5) We simplifies the personal assessment base with the personal monthly wage prior retirement.

Share of opted-out pension from PAYG on total (potential) PAYG pension is calculated as (6)

$$I^i_{OPT-OUT} = \left(\frac{n^i_{FDC}}{n_1} * \frac{cr_{FDC}}{cr} * \theta^i\right) \approx \left(\frac{n^i_{FDC}}{40} * \frac{6}{21} * 1\right) \tag{6}$$

Where n^i_{FDC} is the saving period in FDC system, cr_{FDC} is the opted-out contribution rate (set at 6%) and θ^i corresponds with the restriction of pension rights from PAYG DB system in case that individual chooses to opt-out. If $\theta^i > 1$, than the system financially penalize the individuals who have chosen to opt-out. We set $\theta^i = 1$.

2. FDC Model

FDC micro-simulation model has two parts (phases) – saving and pay-out phases. The equations of the model are based on insurance-mathematical relations (the saved amount and the present value of future payments are equal):

$$S^i = NV^i_{RA} \tag{7}$$

2.1 Saving Phase

$$S^i = \sum_{j=1}^{n_1} \left[\left(12 \cdot W^i_j \cdot cr_{FDC}\right) \prod_{k=j+1}^{n_1} \left(1+\pi_k\right)\left(1+r_k\right) \right] * (1 - ncp) \tag{8}$$

S^i – value of pension actives of an individual (i^{th} income percentile) at the moment of retirement

W^i_j – monthly salary of i^{th} income percentile in the year j of work career

cr_{FDC} – contribution rate to the FDC system (cr_{FDC} = 6%)

n_1 – saving period (n_1 = 40)

π_k – inflation rate in the year k

r_k – real appreciation rate in the year k

ncp – the share of non-contributory period within the saving period

2.2 Pay-out Phase

$$NV^i_{RA} = 12 \cdot P^i_{FDC} \left[1 + \sum_{l=1}^{n_2-1} \prod_{m=1}^{l} \frac{1+v_m}{\left(1+\pi_m\right)\left(1+r_m\right)} \right] \tag{9}$$

NV^i_{RA} net present value of future paid pensions (individual in percentile i, at the time of retirement – Y)

P^i_{FDC} the first assessed pension at the time of retirement (monthly)

n_2 the life expectancy at the time of retirement (length of pay-out phase)

v_m pension adjustment in the beginning of the year (m+ 1) after the retirement

π_m inflation rate in the year m after the retirement

r_m the real rate of return in the year m after the retirement

Pension adjustment

$$1 + v_m = (1 + \pi_m) * (1 + \frac{rw_{m-1}}{3}) \tag{10}$$

rw_{m-1} the real growth of the average wage in the year (m – 1)

Pension adjustment follows the Section 67 of the Act No. 155/1995, Coll. Since the rule of pension adjustment does not influence NV^i_{RA}, the rule from the PAYG DB pensions is used for convenience.

3. Projection of the Income Differentiation until 2050

$$DR_{2008} = \frac{W^{90}_{2008}}{W^{10}_{2008}}, \; DR_{2050} = \frac{W^{90}_{2050}}{W^{10}_{2050}} \tag{11}$$

$$I_{DR} = \frac{DR_{2050}}{DR_{2008}} \tag{12}$$

Income differentiation is measured by the "decile ratio" (the share of the ninth to the first income decile). DR_{2008} is given by the CSO (2009), DR_{2050} is our "desired" ratio in 2050 (at the level of 3.5).

$$\overline{rw} = \left[\left(\prod_{j=2009}^{2050} (1 + rw_j) \right)^{\frac{1}{42}} - 1 \right] \tag{13}$$

$\overline{rw}$ denote average real growth of the average wage between 2008 and 2050.

$$W^i_a = W^i_{2008} * \prod_{j=2009}^{a} \left[(1 + \pi_{j-1}) * (1 + rw_{j-1} + (i - 67) * x) \right] \tag{14}$$

Formula (14) expresses the projection of wages according to desired development of the Income Differentiation. We assume that the wage growth until 2050 of the 67th income percentile will be the same as the wage growth of the average wage (more or less true for the years 1993–2007). We apply "the correction coefficient of the wage growth – x" for other income percentiles. The higher (lower) income percentile (compared to the 67th income percentile), the more important role plays the "correction coefficient of the wage growth". For simplification and convenience we have replaced rw_j with $\overline{rw}$ in the formulas (15) and (16), which has helped us to find "the correction coefficient of the wage growth".

$$I_{DR} = \frac{DR_{2050}}{DR_{2008}} = \frac{\dfrac{W_{2008}^{90} * \prod_{j=2009}^{2050} \left[(1+\pi_j)(1+\overline{rw}+(90-67)*x) \right]}{W_{2008}^{10} * \prod_{j=2009}^{2050} \left[(1+\pi_j)(1+\overline{rw}+(10-67)*x) \right]}}{\dfrac{W_{2008}^{90}}{W_{2008}^{10}}} = \cdots$$

$$\cdots = \prod_{j=2009}^{2050} \frac{\left[1+\overline{rw}+(90-67)*x \right]}{\left[1+\overline{rw}+(10-67)*x \right]} = \left(\frac{1+\overline{rw}+(90-67)*x}{1+\overline{rw}+(10-67)*x} \right)^{42} \tag{15}$$

$$x = \frac{(1+\overline{rw})*(I_{DR}^{\frac{1}{42}}-1)}{\left[(90-67)-(10-67)*I_{DR}^{\frac{1}{42}} \right]} \tag{16}$$

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