

Working Paper No. 01/2011

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**Ukrainian Pension Reform in the Context of Population Ageing: A Dynamic CGE
Approach**

February 2011



1. Introduction

Ukraine has a rapidly ageing and declining population. By the beginning of 2010 the total population has decreased by 12% since 1993, when it reached its peak of 52 million. According to population projections¹, the share of the pension age population will increase from 24% in 2005 to 38% in 2050. At the same time, the share of the working age population will decrease from 54% to 44%.

Such a significant and rapid change in population age structure will likely have a number of macroeconomic effects. It will certainly change the demand composition, as consumption preferences vary by age. It will also affect national savings, as at different stages in their life cycles people have different savings propensities. There will be significant impacts on the size, composition and productivity of the labour force. Population ageing may even potentially affect the speed of technological progress.

This paper concentrates on the effect of the interaction of the declining labour force and the growing number of pensioners on the macroeconomy. The topic is especially timely because of the revived discussion about pension reform in Ukraine. It has long been recognized that the current design of the pension system is subject to high demographic risk and its Pay-As-You-Go (PAYG) component is not sustainable in the long run. Nevertheless, all previous attempts at reforming the system were only half hearted and did not address its major problems. Major reason for that was political instability in the country and the reluctance of the political elite to disturb pensioners – a large, growing and very politically active part of the population. However, recently a combination of economic crises and pressure from the IMF has resulted in more serious and bold discussion of pension reform than ever. Currently a new piece of legislation, changing the rules determining pension system participation and eligibility, is being discussed in Parliament. The biggest change proposed is an increase of pension eligibility age for females by 5 years over the next 10 years from current level of 55 years to 60 years. The pension eligibility age for males is supposed to remain unchanged at 60 years.

This paper uses the dynamic CGE model of Ukraine to run simulations of the proposed changes to the PAYG component of the pension system. It is a standard forward-looking model with intertemporal optimisation and perfect foresight with an explicitly modelled PAYG Pension Fund.

¹ Discussed in section 4.



The effect of an ageing population structure is modelled by the interaction of three processes: a declining labour force (which affects labour supply and through it output), an increasing proportion of pension age population (which affects the size of the outstanding pension benefits) and a declining total population (which affects the size of the government consumption).

Under the baseline scenario, which models population ageing and no changes in the pension system, by 2060 consumption per capita will have declined by 19% and GDP per capita by 17% relative to the benchmark, with no change in population age structure. The share of government spending will have increased from 24% of GDP in the first period to 29% by 2060, and the effective rate of workers' pension contributions from 17% of the labour income at the beginning to 28% in 2060.

Analysis of the potential changes to the pension system is limited to modelling an increase of the pension eligibility age, keeping either the workers' contribution rate or replacement rate constant. If the replacement rate is kept constant and pension eligibility age is increased to 65 years for both sexes, then the effective rate of workers' pension contributions would have to increase from 17% to 20% at the highest point. If, on the other hand, the workers' contribution rate is held constant and pension age is increased in the same way, then the replacement rate drops from 33% to 22% by 2060. Increasing the pension eligibility age for females to 60 years also has a positive effect on macroeconomic variables and the pension system, but it is much smaller.

The rest of the paper is organized as follows. Section 2 presents an overview of the Ukrainian pension system. Section 3 gives brief descriptions of the model, calibration and data. Section 4 describes simulations, scenarios and presents results. Section 5 concludes with a discussion of the results and the policy implications.

2. Overview of the Ukrainian Pension System

2.1. Background

The Ukrainian pension system was created on the basis of the former USSR pension system. It was a one level system operating mostly on the Pay-As-You-Go (PAYG) principle: i.e. benefits of most of current pensioners are financed by contributions of current workers. Pensions or parts thereof of some categories of workers are paid out of the state budget. In 2003, Ukraine started the process of comprehensive pension system reform. One of the important reasons for this reform was anticipated population ageing and the view that a PAYG Pension Fund is subject to very high demographic risk. The law "On Mandatory State Pension Insurance" has introduced the three-tier system



recommended by the World Bank (1994) and supported by reforms in more advanced transition economies (Kazakhstan, Hungary – 1998, Poland – 1999, Latvia – 2001, Croatia, Estonia, Russia – 2002).

The first tier is the mandatory PAYG component (the existing system repackaged), complemented by the mandatory funded second tier (operated by government) and voluntary funded third tier (privately operated). The third tier has been functioning since 2005, although the participation rate is very low. Introduction of the second tier is conditional on reforming the PAYG component and has been postponed several times. The law “On Mandatory State Pension Insurance” does not stipulate when the second tier has to come into operation, only the conditions that are required for it to do so. One of the reasons why the second tier still exists only on paper is the unbalanced PAYG component.

The reform that started in 2003 stalled in the run-up to the presidential elections in 2004, when pensions were increased sharply. Between January and September 2004, the minimum pension increased from UAH102.8 to UAH284.6 – an increase of 177% – and by the end of 2004 around 83% of pensioners were receiving the minimum pension (Institute for Economic Research and Policy Consulting (IER), 2006). After this increase, in 2005 the balance of the Pension Fund turned negative (for the first time), with a deficit reaching 25%. According to the most recent data in 2010 the deficit of the Pension Fund reached 17% of total expenditures.

The main goal of the new round of pension reform in Ukraine, discussion of which started in 2010, is to achieve a balanced PAYG Pension Fund.

2.2. Revenue side

The Pension Fund of Ukraine has two major sources of income: workers’ contributions and state budget contributions. In 2010, workers’ contributions accounted for 72% of total revenues, state budget contributions accounted for 23% and the remaining 5% came from other sources. Government contributions cover the pensions of some categories of workers, e.g. retired military servicemen and judges. However, these mandatory state budget contributions do not include deficit financing which, as was mentioned before, in 2010 amounted to 17% of total expenditures.

Workers’ contributions consist of two parts. The employer pays the largest part: 33.2% on top of the gross wage. The employee pays 2% of their gross wage. The employee’s



contributions are subtracted from the gross wage, while the employer's contributions are calculated on top of the gross wage; i.e. total labour cost for an employer including pension contributions is 133.2% of the gross wage.

2.3. Expenditure side

The current old-age pension eligibility age in Ukraine is 55 years for females and 60 for males. To be eligible for the minimum old-age pension, males have to have 25 years of working records and females have to have 20 years of records. For every additional year of work exceeding this minimal requirement, the pension increases by 1%. If a person has only a fraction of the minimal required working records, the pension is calculated proportional to the minimal old-age pension level. The minimal old-age pension is set as equal to the subsistence minimum for a disabled person.

The pension eligibility age was set when the pension system of the USSR was developed in the middle of the 20th century, and it has not been changed since then. Other former USSR republics, with the exception of Russia, Belarus and Tajikistan, have increased the pension age. The pension eligibility age in most OECD countries is 65 years. Iceland, Norway and the United States have a normal pension age of 67 years. Czech Republic, France, Hungary, Korea, the Slovak Republic and Turkey have pension eligibility ages between 60 and 65 years (OECD 2005).

The common argument against an increase in pension eligibility age of males is very low life expectancy. It is true that the life expectancy at birth for males is very low: in 2005 it was only 62.2 years, compared with 74 for females (a difference of almost 12 years). However, this can be partially explained by very high mortality among working age males, and at the age of 60, male life expectancy in 2005 was 14.2 years, only 5.3 years below the life expectancy of females. If an increase in pension eligibility age for males is somewhat controversial, then the pension eligibility age for females is clearly much too low. In 2005, life expectancy for females at age 55 was 23.4, i.e. higher than the minimal required number of contribution years. This means that, after contributing for only 20 years, a woman on average can expect to receive benefits for 23.4 years.

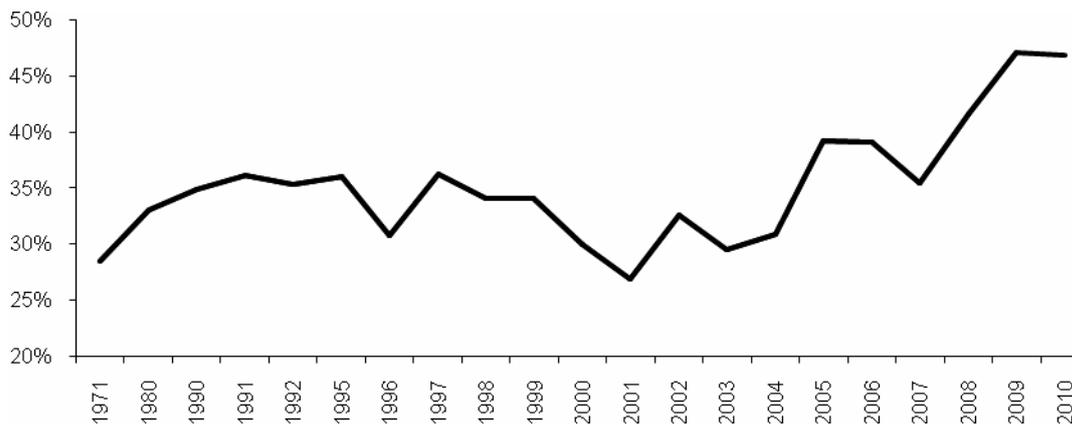
Two mechanisms of pension indexation are in place. A portion of the pension that does not exceed the minimum level is indexed to inflation. The total value of the pension is also partially indexed to wages, and this indexation should be no less than 20% of the average wage increase in the previous year, provided that pensions were growing more slowly than wages.



The replacement rate of average pension to average wage is presented in Figure 1. For most of the period, it fluctuated at around 33%. However, starting from 2005 when pensions were increased for political reasons for the first time, the replacement rate has increased significantly.

Most pensioners receive pensions that are not substantially higher than minimal level. Lack of differentiation is exacerbated by indexation rules, as only the part that does not exceed the minimal level is indexed fully. However, some categories of workers are entitled to privileged pensions that are regulated by special legislation and significantly exceed the minimal level (e.g., people’s deputies, state officials, judges, public prosecutors, investigators, scientists and journalists).

Figure 1. Replacement rate



Source: State Statistical Committee of Ukraine

Such an arrangement creates incentives for participants to pay the minimal possible contributions for a minimal possible period. An illegal but widespread method of avoiding paying pensions contributions (and other taxes) is to pay a fraction of the wage “in an envelope”, i.e. unregistered and without paying social security contributions on this amount. Because both employers and employees are not interested in making high contributions to the pension system, such illegal practices persist. As the result of this, in 2002 the effective workers’ contribution rate was 20%, while the standard rate was 34% (32%+2%) of gross wage. This is calculated based on the size of workers’ pension contributions, taken from the Balance of the Pension Fund, and employees’ compensation, taken from the Social Accounting Matrix (SAM).



2.4. Proposed changes

The most important of the changes proposed in a current round of pension reform are the following:

- increase in female pension eligibility age from current level of 55 years to 60 years during the next 10 years (by half a year ever year)
- increase in minimal required working records for males/females from 20/25 years to 30/35 years
- restriction of maximum pension size by 12 times the minimum pension
- introduction of the second tier of the pension system – mandatory funded component – starting from the year in which PAYG system will be balanced. All workers older than 35 years old will be paying contributions to individual accounts. The contributions will be redirected from the PAYG tier, starting from 2 percentage points and increasing by 1 pp every year until they reach 7 pp of gross wage.

These changes, if implemented, should increase the stability of the Pension Fund. The current government claims that the PAYG fund will be balanced by 2015.

3. Model Description and Calibration

3.1. Model description

The model developed for simulations is an intertemporal dynamic CGE model of a small open economy. There is perfect foresight and no money illusion. The model does not include monetary variables and all value variables are in relative prices. The discounted utility of the infinitely living household is maximized by choosing the optimal level of consumption and investment.

There are four agents: the household, the firm, the government and the rest of the world (ROW).

The household has an additive utility function which it maximizes over the infinite time horizon subject to infinite time budget constraint. There are five main sources of household income: labour income, capital rent, pension benefits, other transfers from



government and transfers from the ROW. The total income in each period is divided amongst income tax, consumption and household savings.

The firm belongs to the household, and produces one product. The firm uses two primary production factors (capital and labour) and intermediate inputs in the production process. Technology is characterised by a nested production function. Value added is produced by the Cobb-Douglas aggregation of capital and labour, and final output is produced by a Leontief function of intermediate input and value added. The technology exhibits constant returns to scale.

The firm chooses the level of investment to maximize the value of the company, subject to the capital accumulation constraint. The value of the company is a net present value of the future dividends. Capital is accumulated in the process of investment and depleted by depreciation. Investment is financed from three sources: household savings, government savings and foreign savings. Investment expenditures include both acquisition and adjustment costs (quadratic in investment).

The government accumulates revenues from taxes (income and indirect tax) and transfers from the ROW, and spends them on goods and services (government consumption), investment, transfers to the household and government pension contributions. The government balances its budget every period by adjusting the indirect tax rate. Various assumptions can be made about the dynamics of the different components of government spending.

The trade between the domestic market and **the ROW** is driven by the imperfect substitution between domestic and foreign goods. Based on the small country assumption, the country is a price taker in international trade. The final product is allocated between domestic sales and exports through constant elasticity of transformation (CET) function. Total absorption is an Armington composite of domestic product and import, and is divided between four uses: private consumption, government consumption, intermediate input and investment.

The PAYG component of the **pension system** is explicitly modelled. Pension revenues are financed from labour income (workers' pension contributions) and government budget (government pension contributions). The two policy parameters of the pension system are replacement rate (relative size of average pension to average wage) and effective workers' pension contribution rate. Fixing one of them determines the value of the other, given the number of pensioners.



In each period, the model has to reach equilibrium in product and factor markets, given assumptions about exogenous variables (discussed below with scenarios). It is assumed that markets are perfectly competitive. The model is implemented in GAMS. A detailed algebraic description of the model is presented in Appendix 1.

3.2. Calibration

The model is calibrated on the basis of the 2002 Ukrainian Social Accounting Matrix (SAM) constructed by the Institute for Economic Research and Policy Consulting. The matrix was adjusted to take into account the specification of the model.

The calibration is based on the assumption that the initial data point is on the steady state growth paths. This is the standard approach in these types of models, and it allows the tracking of changes originating from the specified scenarios. In the final period of the simulation, the model has to return to steady state. This is ensured by the use of terminal conditions. On a steady state, the economy grows at the rate of population growth and capital stock grows at the rate of population growth plus depreciation.

The complete description of the calibration stage is presented in Appendix 2.

4. Simulations, Scenarios and Results

4.1. Simulations

Simulations are performed as a two-step process: the first is population projections, the results of which in the second stage are "fed" into the CGE model.

Population ageing is introduced in the CGE model by three growth rates obtained from population projections:

- growth rate of the labour force, which together with capital stock determines output. Includes all people aged 20-pension age (different in different simulations) and working pensioners. The number of working pensioners is calculated based on the assumption of constant age-specific share of working pensioners (2004 share) (State Statistics Committee of Ukraine);
- growth rate of the pension age population, which together with replacement rate and workers' pension contribution rate determines the size of the pension payments;
- growth rate of the total population, which determines government consumption and transfers.



The interaction of these three exogenous demographic processes has an impact on the trajectories of the endogenous macroeconomic variables.

It is important to understand that the simulations presented in this paper are not projections or forecasts. They leave aside many factors that will determine the development of the macroeconomic situation in Ukraine and concentrate on just one: population ageing. Thus, the results presented measure the potential impact of this one factor *ceteris paribus*.

4.2. Population projections

The population projections used in these simulations are based on the assumptions of the Institute for Demography and Social Studies at the National Academy of Sciences of Ukraine (2006). The medium variant used in this paper is based on medium fertility and mortality assumptions and zero migration assumption. According to the medium fertility assumption total fertility rate (TFR) will gradually increase from 1.21 in 2005 up to 1.50 in 2025 and will stay at about this level thereafter. According to the medium mortality assumption male life expectancy will increase from 62.2 in 2005 up to 71.5 in 2050 and female life expectancy will increase from 74.0 up to 79.5.

Zero migration is close to the low migration scenario of the Institute for Demography and reflects recent trends. An inflow of working-age migrants would improve the situation. However, it is unadvisable to base long-term economic analysis on hopes for high immigration. It is especially difficult to project migration flows for countries like Ukraine, where past trends show a mixed picture and future trends will depend on the results of economic transition, which is still in progress. Thus, depending on whether one believes that Ukraine will attract migrants in the future or lose population as a result of emigration, the results discussed below present a lower or upper boundary of potential outcomes. Table 1 summarizes the changes in selected age group according to presented population projections.

Table 1. Changes in selected population groups

Scenario		Natural change only
Population 0-19	2005	10689
	2050	5936
	% Δ	-44%
Population 20-64	2005	28904
	2050	18853
	% Δ	-35%
Population 65+	2005	7507
	2050	8483
	% Δ	13%
Total population	2005	47100
	2050	33273
	% Δ	-29%

4.3. Steady state and stable population

As mentioned above, the model is structured and calibrated under the assumption that in the initial and final periods, the economy is in a steady state. This means that key economic variables grow at the same rate: the population growth rate and therefore per capita variables do not change. There is no productivity growth in this model. If it had been included, then, in a steady state, variables would grow at the rate of the population growth plus total factor productivity growth, and per capita variables would grow at the rate of total factor productivity growth. A steady state is only possible if all population groups grow at the same rate: i.e. population age structure does not change.

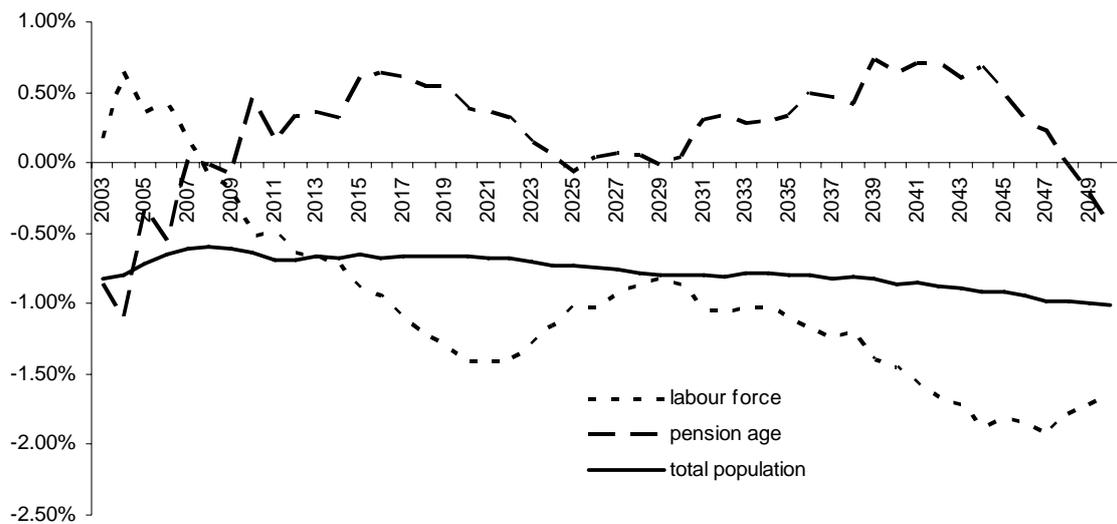
This was obviously not the case in Ukraine in 2002. Assuming this, however, is a necessary and useful starting point. Starting from this point, we will track changes associated with the “additional” population ageing that will happen after 2002. This assumption is only critical during the calibration stage when the level of initial capital stock and depreciation rate are calculated. All other variables and parameters are unaffected by this assumption. Out of steady state calibration would make things more complicated, but would not significantly change the results.

To ensure that in the final period of simulations a steady state is achieved, population projections have to be extended until the moment when Ukraine reaches a stable population. This can be called the “demographic steady state”, as age structure of the population is constant and each population group grows at the same rate, which is equal



to the growth rate of the total population. A population with any age structure will reach stable state in about a lifetime of one generation if it experiences stable fertility and mortality rates, and if there is no migration or if the age structure of migrants corresponds to the age structure of the population. The Institute for Demography currently makes demographic assumptions only until 2050. At the end of this projection period, Ukraine is still far from having a stable population (see Figure 2).

Figure 2. Historical and projected growth rates of population groups, 2003-2050

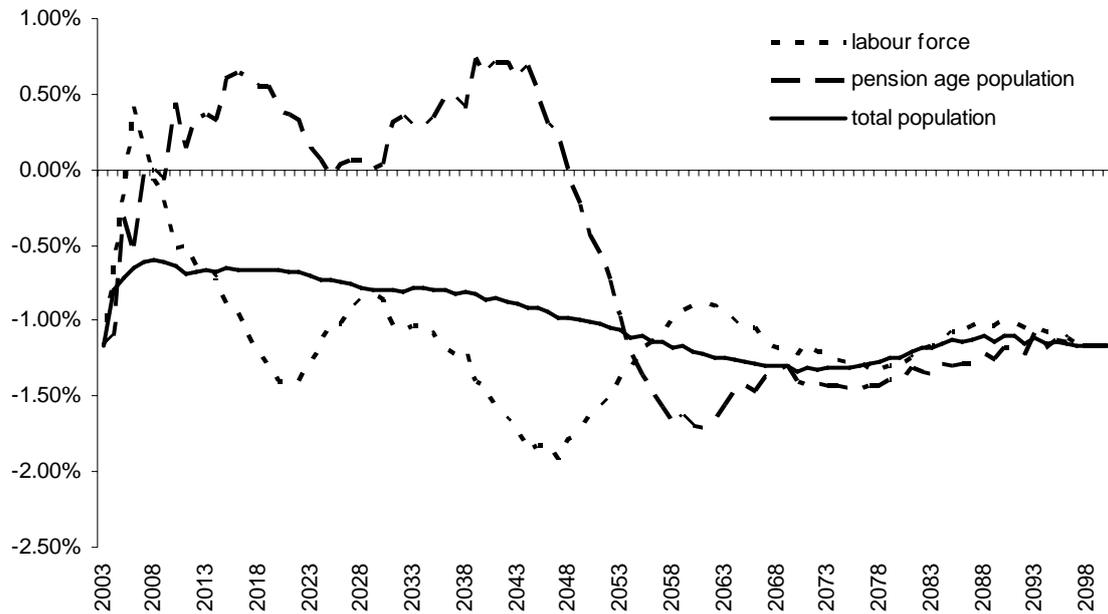


Source: State Statistical Committee of Ukraine, own projections

To ensure that in the final year of simulations Ukraine will reach a stable population, population projections were extended for another 45 years under the assumption that, after 2050, fertility and mortality rates will not change and there will be no migration. Growth rates of the key population groups, with some smoothing in the initial and final years, are presented in Figure 3.



Figure 3. Projected growth rates of population groups 2003-2100



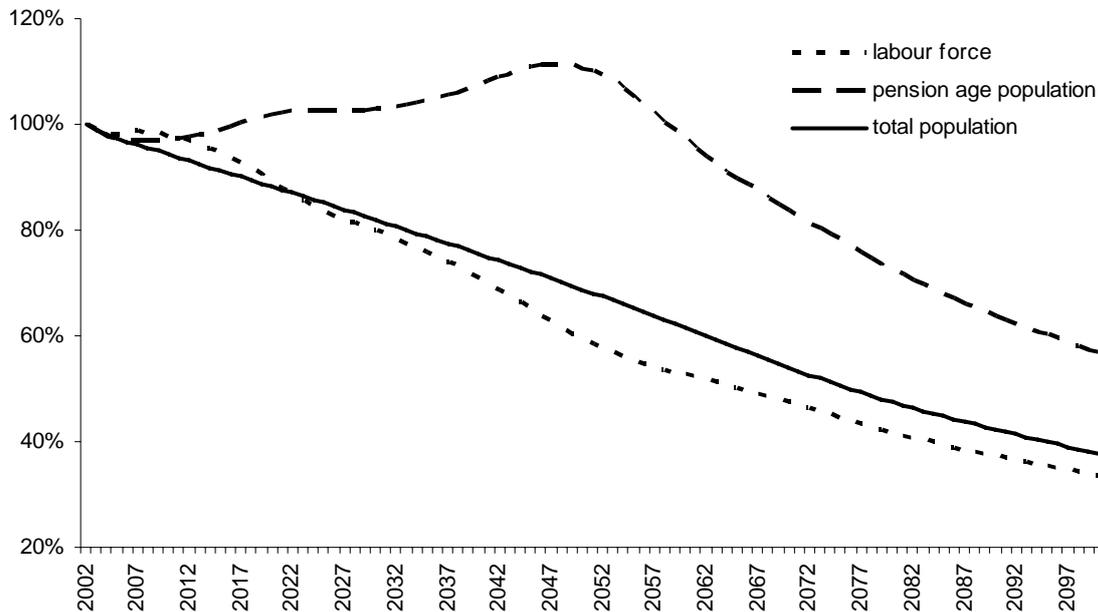
Source: State Statistical Committee of Ukraine, own projections

From these growth rates, the model calculates the size of the labour force, the amount of pension benefits due to be paid out and the size of government consumption and transfers for each period of the simulation. The cumulative change in the demographic exogenous variables is presented in Figure 4. Over the projection period, the labour force will shrink by 66%, the pension age population by 43% and total population by 62%. The deviation of working age population and pension age population decline from the total population decline represents population ageing.

One has to keep in mind that population projections were extended for 100 years only for analytical reasons (requirements of the model set-up). It is impossible to say anything credible about what will happen with demographic situation in Ukraine (like in any other country) in such a distant future. Thus, although the results will be reported for the whole simulation period, closer attention should be paid to the first part of the period. This projection, based on the assumption of constant fertility and mortality patterns after 2050, however, serves one more useful purpose. It shows how unsustainable the current demographic situation is and how quickly a country of the size of Ukraine can become depopulated.



Figure 4. Change in demographic variables over the simulation period



Source: own projections

4.4. Counterfactual

The choice of counterfactual is very important in CGE studies and depends on the research question under investigation. If selected correctly, it will isolate the effect of the factor that the researcher is interested in. If not, the results will show a mixed picture influenced by several factors.

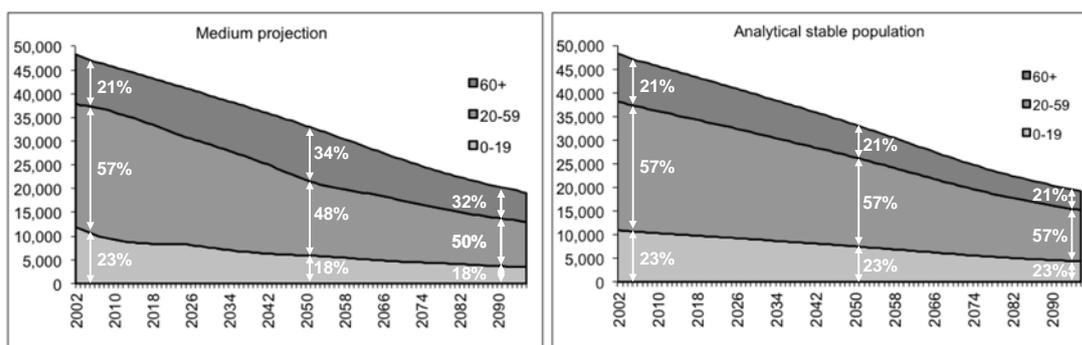
This study is concerned with the effect of population ageing, i.e. change in the age structure of the population. Thus, the counterfactual should be based on the same assumptions, only with no population ageing. The results of simulations are presented relative to the base run with no population ageing (an approach similar to the one used by Fougère *et al.*, 2009). In the base run, the total population is the same as in the simulation scenario but the age structure of the population is fixed: i.e. each age group declines at the same rate as the total population. This is called the “analytical stable population” because, although it satisfies the definition of a stable population (constant age structure), it is not projected based on the fertility, mortality and migration assumptions that would guarantee its stability. Moreover, while the rate of growth of all age groups is the same, it is not constant over time.



Using a stable population as a benchmark is useful because it allows the isolation of the effect of changing age structure from the effect of population decline. In effect, it is equivalent to analysing the results in per capita terms. That is why the GDP and household consumption that are reported in both aggregate and per capita terms show the same relative dynamics.

Figure 5 illustrates the concept of analytical stable population. The left panel presents population projection and the right panel the corresponding analytical stable population. In presented population projection, the share of working age population increases in the initial years of the projection as a result of the rapid decline in population aged 0-19. In about 40 years, the same rapid decline is repeated for the working age population. During the simulation period, the share of the population aged 20-59 declines from 57% to 50%, and the share of population aged 60+ increases from 21% to 32%. In the analytical stable population, the age composition does not change.

Figure 5. Population projection and analytical stable population



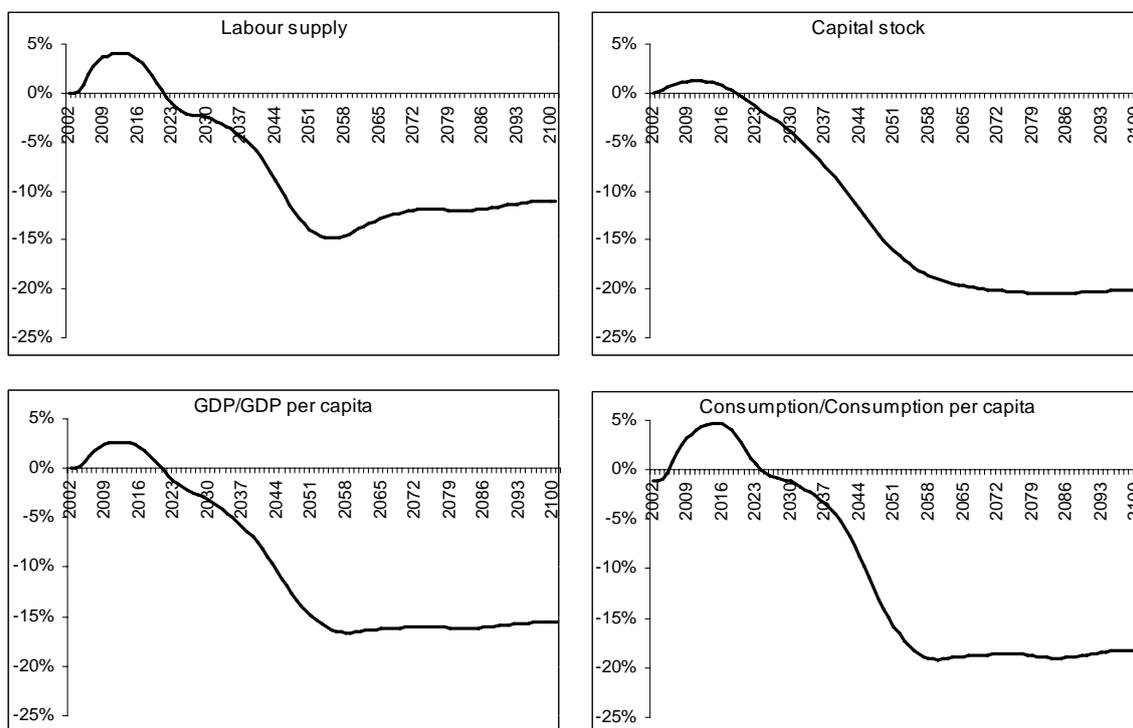
4.5. Baseline scenario

The baseline scenario is based on the demographic scenario described above. It applies the rates presented in Figure 3 to exogenous variables. The Pension Fund is financed on a PAYG basis, except for the constant fraction of government pension contributions fixed at the 2002 level (13%, obtained from the Pension Fund balance). The replacement rate is constant at the 2002 level (33%). This scenario can be viewed as a *status quo* situation. It shows what would happen if no actions are taken and the demographic situation develops according to the presented demographic scenario. The results of the baseline scenario are summarized in Figures 6-8. All results are presented as a percentage difference with the stable population scenario, unless specified otherwise.



The labour supply is an exogenous variable and is the driving force of the change in the other macroeconomic variables presented in the first panel (Figure 6). The capital stock adjusts in line with labour supply, but much more smoothly. This is because investments are subject to quadratic adjustment cost; i.e. capital cannot adjust to a new equilibrium level instantly. As was explained before, because the results presented are relative to the stable population scenario, aggregated variables and per capita variables display the same relative dynamics.

Figure 6. Results for base line scenario (1)



Consumption per capita and GDP per capita both increase in the initial periods owing to an increasing share of the working age population, and then decline rapidly after 2022. These two variables reach their lowest level around 2060. Consumption per capita declines by 19% and GDP per capita by 17%.

Consumption does not exactly follow the path of GDP, because it depends on the rate of economic growth and short-run interest rates. During the simulation period, the interest rate is allowed to deviate from the long-run world interest rate. This happens because capital stock does not adjust instantaneously to the desired level owing to the existence of adjustment costs. However, the deviation of interest rate is not significant.



The situation with government finances is presented on the second panel of the graphs (Figure 7). Government spending is equal to government revenues in each period. The indirect tax rate adjusts to keep the government budget balanced. After a modest decline in the initial periods, it increases from just above 12% in the first period to 18% at its maximum in 2057, levelling off later at just below 17%. Following the same pattern, the share of government spending increases from 24.4% of GDP in the first period to 29.4% in 2057. By the final period, it slightly decreases to 28.7%.

Figure 7. Results for base line scenario (2)

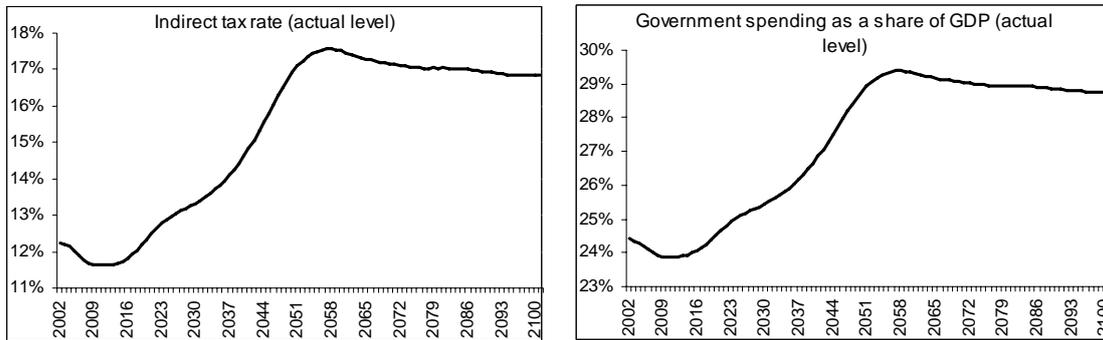
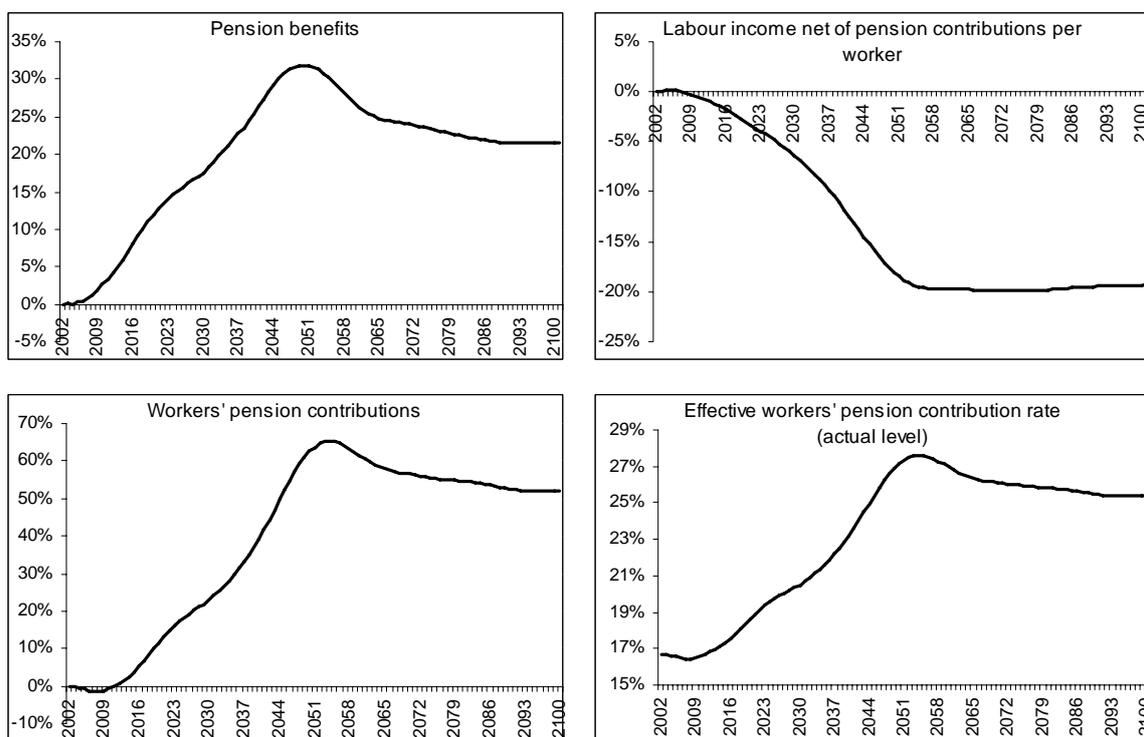


Figure 8 presents the third panel of results of the baseline simulation. In this group of charts, the exogenous variable is the aggregated level of pension benefits. It depends on two variables: the number of pensioners and the replacement rate. As mentioned above in the baseline scenario, the replacement rate is held constant at the 2002 level (33% of the average wage).

As the population ages, the total amount of pension payments increases compared with the stable population level, exceeding it by 32% around 2050. At the end of the simulation period, they reach a new long-run level, although, owing to the changes in age structure of the population, it is 22% above the stable population level.



Figure 8. Results for base line scenario (3)



In the baseline scenario, 87% of pension payments are financed on a PAYG basis. The remaining 13% are financed by government. To finance benefits paid out to a proportionately increasing number of pensioners, workers have to contribute a growing proportion of their labour income. The effective rate of workers' pension contributions increases from 20% of the gross wage at the beginning, to 33% at the end of simulation period, peaking at 37% in 2054.

Thus, the baseline scenario shows that population ageing may lead to a significant decline in consumption per capita, deterioration of public finances and an increase in the pension system burden on the economy.

4.6. Modelling pension system

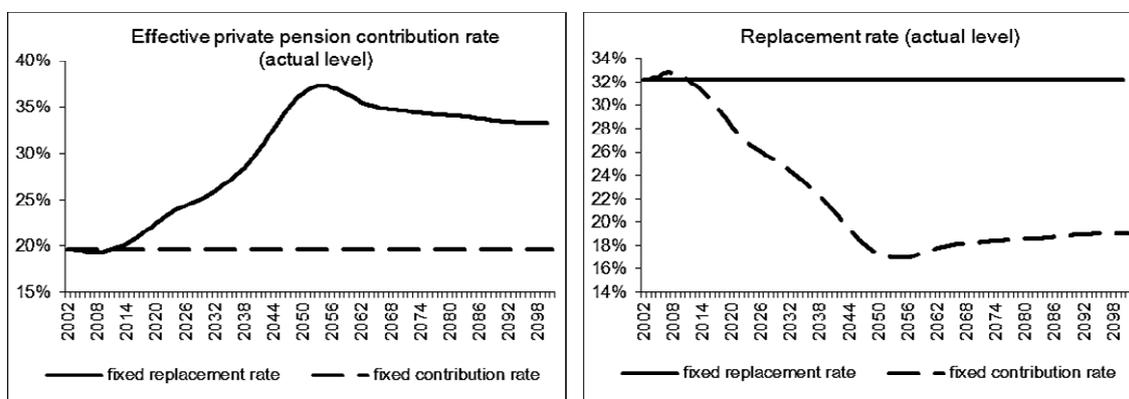
Three variables determine the size of the contributions and the size of the benefits in the PAYG Pension Fund: workers' pension contribution rate, replacement rate and pension age. Fixing any two of these determines the size of the third one. In the following sections, the simulation results for different pension system scenarios are presented.



No change in pension eligibility age

If pension eligibility age is not increased, there are two options for keeping the Pension Fund balanced without an increase in state contributions: increase workers’ pension contributions (baseline scenario) or decrease the replacement rate. Figure 9 summarizes these two options. In the former case, the effective rate of workers’ pension contributions would have to be increased from 20% to 37% by 2050. In the latter case, the replacement rate would have to decrease from 33% to 17% by the same period.

Figure 9. Scenarios with no change in pension eligibility age



From the perspective of political economy, both of these options are infeasible. These hypothetical scenarios are presented here to illustrate the extent of the problem. It is obvious that an increase in pension eligibility age is not only necessary but also inevitable.

Increase in pension eligibility age

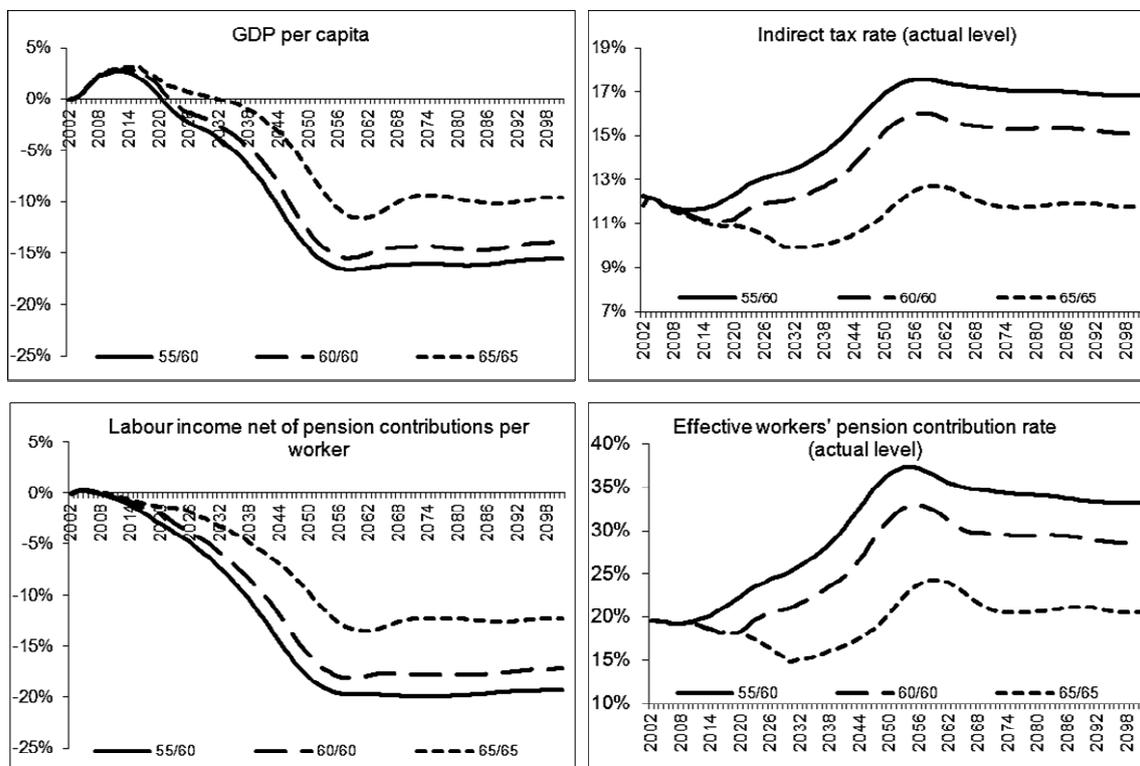
Two types of scenarios of increase in pension eligibility age are modelled:

- Increase of pension age for females to 60 (as envisaged in current pension reform);
- Increase of pension age for males and females to 65.

In each case, the pension age increase starts in 2011. In each case, pension age is increased gradually by half a year each year: i.e. for the first scenario, it takes 10 years for the female pension age to increase from 55 to 60 years. In the second scenario pension eligibility age for males starts to increase after pension eligibility age for females reaches 60 years, i.e. in 2020.



Figure 10. Scenarios with increase in pension eligibility age (fixed replacement rate)



The results of these scenarios together with the baseline are presented in Figure 10. In all of these simulations, the replacement rate is held constant. An increase of pension age for females to 60 years has only a small positive effect on the pension system, distribution of income between workers and pensioners, GDP per capita and government finances.

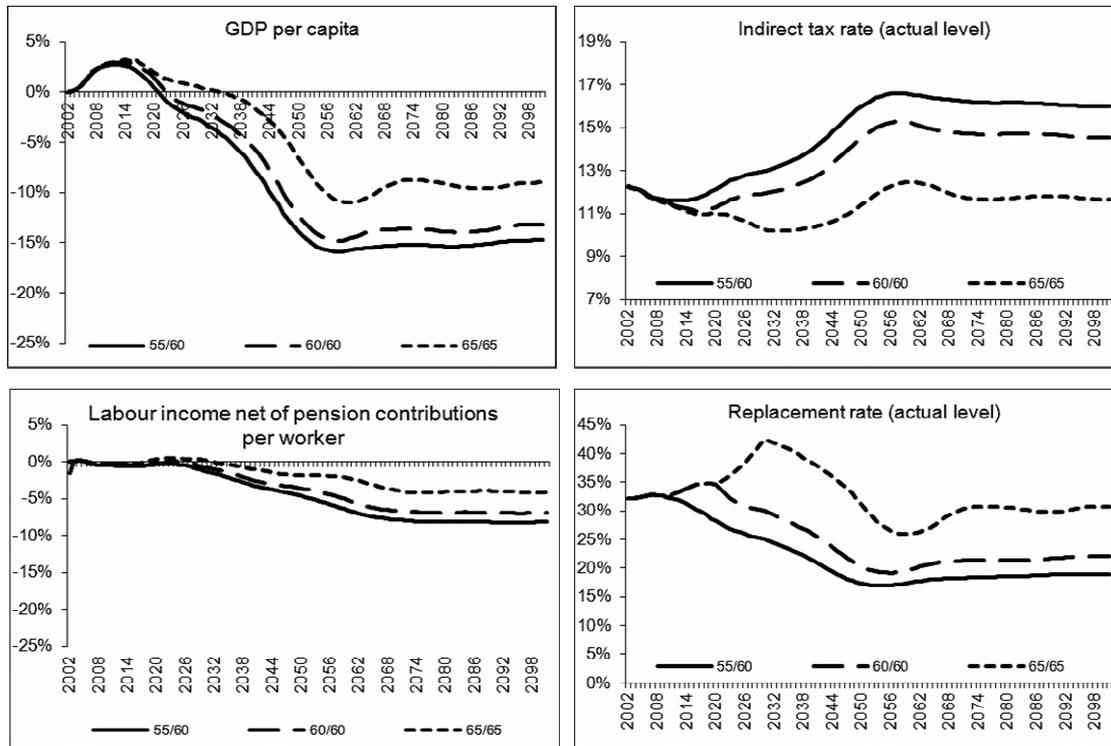
A gradual increase of pension age to 65 years for both sexes has a greater positive impact. GDP per capita by 2055 declines by 10% compared with 17%, if the pension age is not changed. The indirect tax rate exceeds the initial level for only 10 years (in the middle of the simulation period). The labour income net of pension contributions per worker declines by 13% by 2055 compared with 20% in the baseline case. The effective rate of worker pension contributions would have to increase to 24% at the highest point, and at the beginning of simulation period it could be reduced.

The results for the same three scenarios with a fixed contribution rate are presented in Figure 11. The dynamics of the GDP per capita do not change. The indirect tax rate is lower in all three scenarios, as government spending is lower as a result of lower state pension contributions. The labour income net of pension contributions per worker



declines much less: by 8% if the pension age is not changed, or by 4% if the pension age is increased to 65 years for both sexes.

Figure 11. Scenarios with increase in pension eligibility age (fixed contribution rate)



The replacement rate in the baseline scenario decreases from 33% to 17% by 2050. If the pension age for females is increased to 60 years it decreases to 19%, and if the pension age is increased to 65 years for both sexes to 22% during the same period (after the initial significant increase).



5. Conclusions

The work undertaken in this paper is an attempt to model the demographic change in Ukraine with special focus on the pension system. The chosen intertemporal CGE approach proved useful for evaluating expected changes and broad quantification of the impact. The model developed is rather simple, but provides very important first results.

According to population projections, the Ukrainian population is going to decline and age rapidly during the next 50 years. This will have important consequences for the Ukrainian macroeconomic outlook. The Ukrainian pension system, which at the moment is organized on the PAYG principle, will be especially vulnerable as the number of contributors declines and the number of beneficiaries increases.

The simulations presented in this paper model only the first tier of the three-tier pension system that has to be implemented in Ukraine, according to current legislation. They give an insight into which measures should be taken in order to stabilize the existing PAYG system before the second funded tier can be introduced. One obvious conclusion is that the pension eligibility age has to be increased. The currently proposed increase in female pension eligibility age by 5 years to match that of males has a small positive effect on the pension system and the wider economy. According to presented calculations it is enough to balance the Pension Fund by 2015 (which is an ambition of the current government) while keeping both the replacement rate and effective pension contributions at their 2002 level. If the replacement rate is kept constant, then by 2015 effective workers' pension contributions rate can be decreased from the 2002 level of 20% to 18%. Alternatively, if the effective workers' pension contribution rate is kept constant then the replacement rate can increase from 32% to 34%. However, if the actual increase in the replacement rate since 2002 is taken into account, then according to this presented simulation, the Pension Fund will be unbalanced in 2015. Yet CGE models by their nature are less suitable for short-run simulations, and more attention should be paid to longer-term results. Here the picture is clear that increasing pension age for females to 60 years is not enough to sustain the balance of the Pension Fund without significant change to current pension system parameters. By 2050 the effective workers' contribution rate would have to increase to 25% or the replacement rate would have to decrease to 20%.

An increase in pension age to 65 for both sexes significantly improves the stability of the Pension Fund, and has a large positive impact on other macroeconomic parameters. It is



virtually enough to keep the pension system with the current replacement rate and with the current contribution rate.

The second tier of the pension system will be financed by diverting some of the contributions that are currently directed to the PAYG fund. However, the model shows that, if anything, the workers' pension contribution rate has to be increased to keep the benefits at the current level. However, these two contradictory requirements can be met at the same time. At the moment contributions to the Pension Fund are not paid from all of the labour income and a large portion of the economy is in the shadow. As a result, while the standard pension contributions in 2002 were 34% of the gross wage, the effective rate, calculated from the SAM and Pension Fund balance, was only 20%. Thus, it should be possible to decrease the contributions rate to the PAYG fund for those who pay contributions at the moment, and compensate for it by broadening the contribution base, through a reduction in the size of the shadow economy and equal treatment of all labour income.

However, this will only be possible if public trust in the pension system is restored. At the moment, with almost flat benefits, there is little incentive to participate in the system beyond minimal contributions. On top of this, the strong link between the level of pension benefits and the political cycle further decrease this motivation.

In other CEE countries, the introduction of the funded component into the pension system helped to restore its popularity. Plans for similar pension reform have been discussed in Ukraine for many years. Implementation of the reforms is essential, and time is of crucial importance, as the process of population ageing will accelerate in the future. It is important to determine a long-term strategy for a pension system with stable rules, and consistently implement it. The practice that exists now, with *ad hoc* decisions connected to the political cycle, make the system unstable and decrease the incentives for workers to participate in it.



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Appendix 1. Algebraic Description of the Model

List of parameters

Exogenous parameters

rss	Return to capital on the steady state	0.05
ro	Time preference	0.05
adjsh	Share of adjustment costs out of investment	0.01

Calibrated parameters (see Appendix 3)

ty	Income tax rate
io	Leontief technical coefficients
α_K	Capital value share in production function
α_L	Labour value share in the production function
aF	Efficiency parameter in the production function
δ	Depreciation rate
φ	Adjustment cost parameter
INVGshare	Share of government investment in GDP
GPCshare	Share of government pension contributions

Exogenous demographic variables

g	Steady state population growth rate
popgcum _T	Cumulative growth of total population between T ₀ and T
lgcum _T	Cumulative growth of labour force between T ₀ and T
pgcum _T	Cumulative growth of pension age population between T ₀ and T
tpop _T	Total population size at time T
lpop _T	Labour force size at time T
ppop _T	Pension age population size at time T



List of variables

PL_T	Wage rate
PK_T	Price of capital goods
PD_T	Output Price
r_T	Interest rate
$LAMBDA_T$	Lagrange multiplier of the firm
CPI_T	Consumer price index
XD_T	Domestic output
L_T	Labour demand
K_T	Capital stock
INV_T	Investment demand
C_T	Consumption demand
CE_T	Consumption expenditures
Y_T	Household income
LS_T	Labour supply (exogenous)
DIV_T	Total Dividends
GDP_T	Gross Domestic Product
S_T	Total savings
SH_T	Household savings
SF_T	Foreign savings
FD_T	Foreign debt
$TAXR_T$	Total tax revenues
CG_T	Government commodity demand
TRF_T	Government transfers to household
$GREV_T$	Government revenues
$GSPEND_T$	Government spending
$INVG_T$	Government investment
PF_T	Pension Fund



tp_T	Indirect tax rate
PPC_T	Workers' pension contributions
GPC_T	Government pension contributions
pc_T	Workers' pension contribution rate
$repr_T$	Replacement rate
ER_T	Exchange rate
P_T	Price of composite goods (Armington)
PM_T	Price of imported goods in domestic currency
PE_T	Price of exported goods in domestic currency
PWM_T	Price of imported goods in US\$
PWE_T	Price of exported goods in US\$
PDD_T	Price of domestic production delivered to domestic market
XDD_T	Domestic production delivered to domestic markets
X_T	Domestic sales Armington composite
E_T	Exports
M_T	Imports

The model

Firm and Consumer. Intertemporal optimization

$$\lambda_{T+1} = PK_T + \frac{2 * \varphi * PD_T * INV_T}{K_T}$$

$$\frac{\alpha K}{K_T} (PD_T * XD_T - io * XD_T * P_T) * (1 - tp) + \varphi * PD_T * \left(\frac{INV_T}{K_T} \right)^2 - (1 + IR_T) * \lambda_T + (1 - \delta) * \lambda_{T+1} = 0$$

$$K_{T+1} = (1 - \delta) * K_T + INV_T$$

$$\frac{CE_T}{CE_{T-1}} = \frac{(1 + IR_T) * (1 + lg_T)}{(1 + ro)}$$



Terminal conditions

$$INV_{TLAST} = (g_{SS} + \delta) * K_{TLAST}$$

$$\lambda_{TLAST} = PK_{TLAST} + 2 * \varphi * PD_{TLAST} * \frac{INV_{TLAST}}{K_{TLAST}}$$

$$IR_{TLAST} = \rho$$

Intra-temporal optimization and income definitions

$$XD_T = aF_T * K_T^{\alpha K} * L_T^{\alpha L}$$

$$PL_T * L_T = \alpha L * (PD_T * XD_T - io * XD_T * P_T) * (1 - tp)$$

$$PK_T = \frac{1}{\alpha I} * \left(\frac{P_T}{\alpha I} \right)^{\alpha I}$$

$$DIV_T = (1 - tp) * (PD_T * XD_T - io * XD_T * P_T) - \phi * P_T \frac{INV_T^2}{K_T} - PL_T * L_T$$

$$Y_T = DIV_T + PL_T * LS_T + TRF_T + PF_T + TRHROW_T$$

$$NETLY_T = L_T * PL_T - PPC_T$$

$$CE_T = P_T * C_T$$

$$SH_T = (Y_T - PF_T) * (1 - ty) + GPC_T - CE_T$$

$$FD_{T+1} = FD_T + SF_T$$

$$GDP_T = XD_T * PD_T - XD_T * P_T * io$$

Market equilibrium

$$LS_T = L_T$$

$$X_T = C_T + INV_T + io * XD_T + CG_T$$

$$S_T = PK_T * INV_T$$

$$S_T = SH_T + INVG_T + SF_T$$



Government

$$\text{TAXR}_T = \text{ty} * (\text{Y}_T - \text{PF}_T) + \text{tp} * (\text{XD}_T * \text{PD}_T - \text{XD}_T * \text{P}_T * \text{io})$$

$$\text{GREV}_T = \text{TAXR}_T + \text{TRGROW}_T$$

$$\text{CG}_T * \text{P}_T = \text{CG}_{T_0} * \text{P}_{T_0} * \text{popgcum}_T$$

$$\text{TRF}_T = \text{TRF}_{T_0} * \text{popgcum}_T$$

$$\text{INVG}_T = \text{GDP}_T * \text{INVGshare}$$

$$\text{GSPEND}_T = \text{P}_T * \text{CG}_T + \text{TRF}_T + \text{GPC}_T + \text{INVG}_T$$

$$\text{GSPEND}_T = \text{GREV}_T$$

Pension Fund

$$\text{GPC}_T = \text{PF}_T * \text{GPCshare}$$

$$\text{PF}_T = \frac{\text{L}_T * \text{PL}_T - \text{PPC}_T}{\text{lpop}_T} * \text{repr}_T * \text{ppop}_T$$

$$\text{PPC}_T = \text{PF}_T - \text{GPC}_T$$

$$\text{pc}_T = \frac{\text{PPC}_T}{\text{L}_T * \text{PL}_T}$$

or

$$\text{PF}_T = \text{PPC}_T + \text{GPC}_T$$

$$\text{PPC}_T = \text{L}_T * \text{PL}_T * \text{pc}_{T_0}$$

$$\text{repr}_T = \frac{\frac{\text{PF}_T}{\text{ppop}_T}}{\frac{\text{L}_T * \text{PL}_T - \text{PPC}_T}{\text{lpop}_T}}$$



Foreign sector

$$PE_T = PWE_T * ER_T$$

$$E_T = \frac{XD_T - \varphi * \frac{INV_T^2}{K_T}}{aT} * \left(\frac{\gamma T}{PE_T} \right)^{\sigma T} * \left[\gamma T^{\sigma T} * PE_T^{(1-\sigma T)} + (1-\gamma T)^{\sigma T} * PDD_T^{(1-\sigma T)} \right] \left(\frac{\sigma T}{(1-\sigma T)} \right)$$

$$XDD_T = \frac{XD_T - \varphi * \frac{INV_T^2}{K_T}}{aT} * \left(\frac{1-\gamma T}{PDD_T} \right)^{\sigma T} * \left[\gamma T^{\sigma T} * PE_T^{(1-\sigma T)} + (1-\gamma T)^{\sigma T} * PDD_T^{(1-\sigma T)} \right] \left(\frac{\sigma T}{(1-\sigma T)} \right)$$

$$PM_T = ER_T * PWM_T$$

$$M_T = \frac{X_T}{aA} * \left(\frac{\gamma A}{PM_T} \right)^{\sigma A} * \left[\gamma A^{\sigma A} * PM_T^{(1-\sigma A)} + (1-\gamma A)^{\sigma A} * PDD_T^{(1-\sigma A)} \right] \left(\frac{\sigma A}{(1-\sigma A)} \right)$$

$$XDD_T = \frac{X_T}{aA} * \left(\frac{\gamma A}{PDD_T} \right)^{\sigma A} * \left[\gamma A^{\sigma A} * PM_T^{(1-\sigma A)} + (1-\gamma A)^{\sigma A} * PDD_T^{(1-\sigma A)} \right] \left(\frac{\sigma A}{(1-\sigma A)} \right)$$

$$M_T * PWM_T - PWE_T * E_T = (SF_T + TRHROW_T + TRGROW_T) / ER_T$$

Zero profit Armington and CET

$$P_T * X_T = PM_T * M_T + PDD_T * XDD_T$$

$$PD_T * XD_T - PD_T * \varphi * \frac{INV_T^2}{K_T} = PE_T * E_T + PDD_T * XDD_T$$



Appendix 2. Calibration

Initial values from the SAM, SNA and Pension Fund balance

IO_{T_0}	Initial intermediate demand
CZ_{T_0}	Initial household demand
CG_{T_0}	Initial government demand
INV_{T_0}	Initial investment demand
$INVG_{T_0}$	Initial level of government investment
SF_{T_0}	Initial foreign savings
KY_{T_0}	Initial total capital income
L_{T_0}	Initial total labour income
TRF_{T_0}	Initial total government transfers to household
TRP_{T_0}	Initial indirect tax revenues
TRY_{T_0}	Initial income tax revenues
E_{T_0}	Initial level of export
M_{T_0}	Initial level of import
$TRGROW_{T_0}$	Initial foreign transfers to government
$TRHROW_{T_0}$	Initial foreign transfers to households
PPC_{T_0}	Initial workers pension contributions
$GPCZ_{T_0}$	Initial government pension contributions

Parameters

Exogenous parameters

rss	Return to capital on the steady state	0.05
ro	Time preference	0.05
adjsh	Share of adjustment costs out of investment	0.01



Demographic parameters

g	Steady state population growth rate
lg_T	Labour force growth at time T
pg_T	Pension age population growth at time T
$popg_T$	Total population growth at time T
$popgcum_T$	Cumulative growth of total population between T_0 and T
$lgcum_T$	Cumulative growth of labour force between T_0 and T
$pgcum_T$	Cumulative growth of pension age population between T_0 and T
$tpop_T$	Total population size at time T
$lpop_T$	Labour force size at time T
$ppop_T$	Pension age population size at time T

Calibrated parameters

ty	Income tax rate
io	Leontief technical coefficients
α_K	Capital value share in production function
α_L	Labour value share in the production function
a_F	Efficiency parameter in the production function
δ	Depreciation rate
φ	Adjustment cost parameter
INVGshare	Share of government investment in GDP
GPCshare	Share of government pension contributions



Calibration

Initial level of output and capital/labour shares (assuming constant returns to scale)

$$XD_{T_0} = \frac{P_{T_0} * IO_{T_0} + PK_{T_0} * KY_{T_0} + PL_{T_0} * L_{T_0} + TRP_{T_0}}{PD_{T_0}}$$

$$\alpha L = \frac{PL_{T_0} * L_{T_0}}{PK_{T_0} * KY_{T_0} + PL_{T_0} * L_{T_0}}$$

$$\alpha K = 1 - \alpha L$$

Cumulative demographic growth rates and size of population groups

$$lgcum_T = \prod_{T_0}^T lg_T$$

$$pgcum_T = \prod_{T_0}^T pg_T$$

$$popgcum_T = \prod_{T_0}^T popg_T$$

$$lpop_T = lpop_{T_0} * lgcum_T$$

$$ppop_T = ppop_{T_0} * pgcum_T$$

$$tpop_T = tpop_{T_0} * popgcum_T$$

Labour supply equals to labour demand

$$LS_{T_0} = L_{T_0}$$

Adjusting the data for loss in output caused by the adjustment costs

$$C_{T_0} = C_{T_0} - adjsh * INV_{T_0}$$



Calculating initial Pension Fund and related parameters

$$PF_{T_0} = PPC_{T_0} + GPC_{T_0}$$

$$GPC_{share} = \frac{GPC_{T_0}}{PF_{T_0}}$$

$$pc_{T_0} = \frac{PPC_{T_0}}{L_{T_0} * PL_{T_0}}$$

$$repr_{T_0} = \frac{(PF_{T_0}/ppop_{T_0})}{(L_{T_0} - PPC_{T_0})/lpop_{T_0}}$$

Calculating savings and income

$$CE_{T_0} = C_{T_0} * PD_{T_0}$$

$$SH_{T_0} = INV_{T_0} * PK_{T_0} - INVG_{T_0} - SF_{T_0}$$

$$S_{T_0} = SH_{T_0} + INVG_{T_0} + SF_{T_0}$$

$$Y_{T_0} = CE_{T_0} + SH_{T_0} + TRY_{T_0} + PPC_{T_0}$$

$$NETLY_{TFIRST} = L_{TFIRST} * PL_{TFIRST} - PF_{TFIRST}$$

Calculating tax revenue and tax rates

$$TAXR_{T_0} = TRP_{T_0} + TRY_{T_0}$$

$$tp = \frac{TRP_{T_0}}{XD_{T_0} * PD_{T_0} - IO_{T_0}}$$

$$ty = TRY_{T_0} / Y_{T_0}$$



Calibrating technical coefficients

$$iO = \frac{IO_{TFIRST}}{XD_{TFIRST} * PD_{TFIRST}}$$

Calibrating λ based on the assumption that the initial point is on the steady state path

$$\lambda_{TFIRST} = PK_{TFIRST} + 2 * adjsh * PK_{TFIRST}$$

Calibrating initial capital stock based on the first order condition with respect to K

$$K_{T_0} = \frac{(LAMBDA_{T_0} - adjsh * PK_{T_0}) * INV_{T_0} - \alpha K * (XD_{T_0} * PD_{T_0} - iO * XD_{T_0} * PD_{T_0}) * (1 - tp)}{(g - rss) * LAMBDA_{T_0}}$$

Calibrating the adjustment parameter and the depreciation rate

$$\varphi = adjsh * \frac{K_{T_0} * PK_{T_0}}{INV_{T_0} * PD_{T_0}}$$

$$\delta = \frac{INV_{T_0}}{K_{T_0}} - g$$

Calibrating the shift parameter in the output production function

$$aF = \frac{XD_{T_0}}{K_{T_0}^{\alpha K} * L_{T_0}^{\alpha L}}$$

Dividends are a residual after value added tax, adjustment cost and labour income

$$DIV_{T_0} = (1 - tp) * (PD_{T_0} * XD_{T_0} - PD_{T_0} * IO_{T_0}) - \varphi * PD_{T_0} * \frac{INV_{T_0}^2}{K_{T_0}} - PL_{T_0} * L_{T_0}$$



Calculating government revenues and spending

$$\text{GREV}_{T_0} = \text{TAXR}_{T_0} + \text{TRGROW}_{T_0}$$

$$\text{TRF}_{T_0} = \text{TRF}_{T_0} - \text{PF}_{T_0}$$

$$\text{GSPEND}_{T_0} = \text{CG}_{T_0} + \text{TRF}_{T_0} + \text{GPC}_{T_0} + \text{INVG}_{T_0}$$

Calculating initial level of GDP

$$\text{GDP}_{T_0} = \text{XD}_{T_0} * \text{PD}_{T_0} - \text{io} * \text{XD}_{T_0} * \text{PD}_{T_0}$$