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Research Article

Demographic Change and Pension Reform in Ukraine: An OLG Simulation Analysis

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Abstract

The current level of pension provision in Ukraine does not allow a decent life for citizens in retirement. Most of the problems in this area are related to the lack of a scientifically sound social development strategy as a guide for the development of legislation. The aim of this paper is to develop an OLG model of the Ukrainian economy that can be used to study the fiscal effects of demographic changes and to quantify the welfare effects of some currently discussed pension reform proposals. The main factors that hinder the progress of pension reform and adversely affect the functioning of the Ukrainian pension system are demographic changes toward aging of population, labor supply shortage, and capital stock destructions caused by war. The approach to economic modeling is based on an overlapping generation (OLG) model. This paper makes a first attempt to simulate the state of the Ukrainian pension system and economy in the future, taking into account the effects of the proposed reforms of the pension system and excluding the impact of the war and the various forms of support for other countries' economies. As a result, in this study were simulated and evaluated different scenarios for the Ukrainian pension and fiscal system. The main focus is on modeling various demographic scenarios and the resulting implications for overall economic and fiscal development.

Keywords: OLG model, demographic change, economic policy reform, welfare effect.

Introduction

Pension provision is one of the main components of the social security system. The current critical state of the economy, aggravation of social problems, deterioration of the ratio between the working population and pensioners, progressive ageing of the population and deterioration of the demographic situation require appropriate approaches to pension provision. The success of the pension system reform is determined not only by the political expediency of the decisions taken, but also by the degree of their socio-economic soundness.

Even before the current wartime conditions, the demographic upheaval in Ukraine was enormous. Since the collapse of the Soviet

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Union, low birth rates and migration of the working-age population have caused the population to drop from about 51 million in 1991 to the current level of about 41 million in 2021. This development continues and is likely to be exacerbated by war. It is estimated by Ptoukha Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine (2021) that, by 2050, the population will have shrunk even further to around 35 million. It is therefore clear that the situation in the Ukrainian pay-as-you-go pension system is unstable.

The government of Ukraine tried to introduce a funded supplementary pension system more than 15 years ago, but this policy has been very unpopular and inefficient because of an unstable and poorly regulated financial sector. A detailed description and discussion of the problems of the Ukrainian pension system can be found in ILO (2019).

Pension reform began in Ukraine in 2011, together with the reform of the tax and budget system. It mainly concerned an increase in the retirement age for women from 55 to 60 years. Table 1 shows the data characterizing this indicator in some EU countries and Ukraine during 2014-2021. In 2021, Ukraine has an average life expectancy of 72 years, almost on par with Bulgaria and Latvia, while in Denmark, France, Germany, Italy, Portugal, Greece, Finland and Sweden life expectancy is over 80 years with the average age of retirement 63 years. Life expectancy directly affects pension reforms related to retirement age. Therefore, in most EU countries the retirement age is on average 5 years higher than in Ukraine.

Population ageing is common issue for all EU countries, which is increasing, and Ukraine has one of the highest dependency ratios during all these years which is about 41%. Countries such as Italy, Bulgaria, Greece and Finland have dependency ratio above 35% in 2021 and have a similarly acute population aging problem as Ukraine. Almost all EU countries have increased this indicator by 5-30% since 2014.

Table 1: Data on the results of pension reforms in some EU countries[a] and Ukraine[b]

Country	2014			2021		
	retirement age woman/man	life expectancy	dependency ratio, %	retirement age woman/man	life expectancy	dependency ratio, %
Bulgaria	60/63	74.5	30.1	61/64	71.4	36.7
Czechia	60/62	78.9	25.7	62/63	77.2	32.3
Denmark	65	80.7	28.3	67	81.5	31.7
Germany	65	81.2	31.6	66	80.8	34.2
Estonia	63	77.4	27.9	64	77.2	32.2
Greece	65	81.5	31.6	67	80.2	35.6
France	62	82.9	28.3	62	82.4	33.4
Croatia	61/65	77.9	27.7	64/65	76.6	34.9
Italy	65/66	83.2	33.3	67	82.7	37
Latvia	62	74.5	28.8	64	73.1	32.9
Hungary	62	76.0	25.8	65	74.3	31.2
Poland	60/67	77.8	21.2	65/67	75.4	28.9
Portugal	65	81.3	30.3	66	81.5	35
Slovenia	63	81.2	25.7	65	80.7	32.1
Finland	63	81.3	30.2	65	81.9	36.8
Sweden	61	82.3	30.6	62	83.1	32.4
Ukraine	57/60	71.0	39.9	60	72.3	41.3

a Eurostat (2021)
b Pension Fund of Ukraine (2021)

Comparing the directions of reforming the pension system in Ukraine with the experience of EU countries, it can be concluded that most of the problems in this area are related to the lack of a scientifically sound social development strategy as a guide for the development of legislation, orders and resolutions.

Thus, in order to achieve long-term fiscal flexibility to reduce the fiscal pressures associated with population aging, it is necessary to analyze the effect of our proposed reforms to the existing system. This paper makes a first attempt to simulate the state of the Ukrainian pension system and economy in the future, taking into account the effects of the proposed reforms of the pension system and excluding the impact of the war and the various forms of support for other countries' economies due to the current lack of official statistical information for long-run model simulation.

The project to develop a simulation model described in this paper was carried out at the Public Finance Chair at the University of Würzburg within the framework of Volkswagen Foundation over a two-year period under the supervision of Prof. Hans Fehr. The materials of this paper were presented and discussed at the conference and workshop (see Tofaniuk, 2024a; Tofaniuk, 2024b).

The pension system in Ukraine today

Ukraine currently has a relatively generous pay-as-you-go pension system, but population aging coupled with recent problems with economic growth will soon make it unsustainable. Ukraine's population declined by an average of 0.6% annually in 2014-2021 and working population averaged 40.0% of the state's total population during this period. Figure 1 shows that in 2021, the average pension is 29.6% of the average wage income in the country and exceeded the guaranteed income by 1.54 times. The contribution rate to Pension Fund of Ukraine is 18.5 % of salary fund and is paid by employer only.

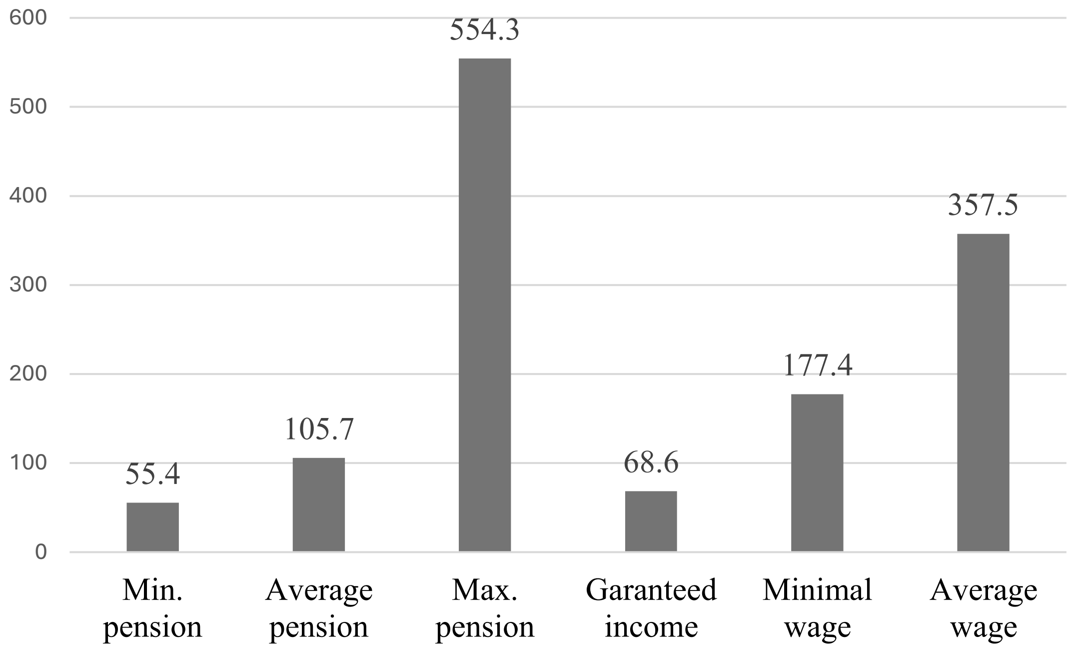

Fig 1. Pension and income indicators in Ukraine 2021, euro

The formula of pension contribution rate has the following form:

$$\tau * \varpi * L = \rho * P \, , \tag{1}$$

where τ – pension contribution rate, ϖ – average wage, ρ – average pension, P – retired population, L - working population. So, the formula of payroll tax equals:

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$$\tau = \frac{P}{L} * \frac{\rho}{\varpi}, \tag{2}$$

and in 2021 pension contribution rate is:

$$\tau 2021 = \frac{10.84}{17.32} * \frac{105.71}{357.52} = 18.52\% \,. \tag{3}$$

Regarding Ukrainian macroeconomic indicators, in 2021 the total amount of pensions paid out by the Pension Fund constituted 6.0% of GDP, and the amount of households' income in GDP is 68.3%. It is worth mentioning that in Ukraine, in addition to pension payments, pensioners receive housing allowances, discounts on medical care and payment of medication, free on public transport services etc.; most pensioners in their 60s are part-time working.

Nevertheless, all these measures do not ensure decent pensions for all segments of the population and pension reform is still in need of reform. It is necessary in order to avoid a deficit in the Pension Fund while the number of pensioners is growing steadily relative to the working-age population. Besides population ageing, the main factors that hinder the progress of pension reform are: the macroeconomic state of the country; high level of "shadow economy"; and high level of labour migration.

The Simulation Model

The approach to economic modelling is based on an overlapping generation model. The OLG model is developed in the seminal work of Auerbach and Kotlikoff (1987). Over the last 40 years, this type of model has been extended in various directions (intragenerational heterogeneity, uncertainty, endogenous growth, etc.). Fehr (2000) developed a very similar model for the calculation of pensions for Germany, then a discussion of various approaches in western countries was provided by Fehr (2016). Verbic (2008) presents a theoretical contribution to the field of overlapping-generations general equilibrium modelling, i.e. an upgrade of this branch of models with Slovenian pension system. . Aysan and Beaujot (2009) evaluate labor force participation of older persons and retirement policies in various welfare regime settings. Buyse et al. (2017) studied the effects of pension reform on hours worked, human capital, income and welfare in an open economy. Tyrowicz et al. (2018) analyze within-cohort heterogeneity of endowments and heterogeneity of preferences in an OLG model with mandatory pension systems in Poland. A similar simulation model was developed by Lisenkova and Bornukova (2018) and simulated effects of raising the retirement age and lowering/higher replacement rates, which is a simplified version without taking into account many factors proposed in this paper. The model calibrates pure rate of time preference, varying with age and has fixed labour supply. In our model, the index of time discount factor is fixed and labour supply is variable. It also contains income classes, varying by level of involvement in work, which effects the pension rate and allows analyzing intragenerational effects of reforms.

The aim of this paper is to develop an OLG model of the Ukrainian economy that can be used to study the fiscal effects of demographic changes and to quantify the welfare effects of some currently discussed pension reform proposals. The theoretical framework is an overlapping generation model, which can be modelled with different demographic scenarios. Future changes in population size and structure have direct and indirect effects on the government budget and macroeconomic variables in the model. The practical implementation of the simulation model in this paper is done using the Fortran 90 language, see Fehr and Kindermann (2018).

The model used in this paper is designed to analyze the long-term economic implications of demographic change. The exogenous demographic process is superimposed on the model and provides the shock or driving force behind the simulation results.

The starting point for the demographic model is a vector with the current population structure, which consists of 80 age cohorts (each cohort is one year), with each cohort divided into three income classes, differing in terms of education level and labour intensity. These classes receive different wages and subsequently different retirement benefits. This vector is then updated with age- and period-dependent fertility and mortality rates, so that we obtain the population trajectory over the simulation period. In this study, the model has production, household and government sectors, is calibrated on the Ukrainian data for a closed economy with an exogenous capital stock and variable labour supply. The model is simulated for 40 years period in a baseline scenario and then in proposed three reforms conditions.

Demographic structure

Demographic variables, fertility, mortality rates in model are assumed to be exogenous. Demographic structure is described by three indices – age, class and period. The age of a specific cohort is denoted by j and the model period consists of one year. The cohort starts working at an age of 20 years, so that each working cohort may live up to $J = 80$ periods (i.e. ages 21–100). Consequently, in each model period there are 80 cohorts where, from period $j = 41$ (age 61), the cohort moves into retirement.

Each cohort is separated into three skill types i or household's classes. These classes have varying intensities of labour throughout their life cycle. The first class, $i = 1$, represents below average value of human capital $h_{i,j}$ and occupies 57.3% of each cohort j. The second class is the so-called middle class, which is targeted by the statistical averages for average wages and pension payments since $h_{i,j}$ is set exogenously, and occupies 38.7 %. The third $i = 3$, so-called elite class, occupies 4 % of the total of each cohort. It is assumed that this class receives income several times higher than average and pension payments for this class are also noticeably higher than the previous two classes. The period is denoted by t. The model starts from a long run equilibrium in period $t = 0$, then, starting in period $t = 1$, fertility and survival rates are adjusted and a transition path to a new long run equilibrium is computed. In each successive period t, a new cohort is born, where the number of households $N_{1,i,t}$ in this cohort grows at a rate np_t. At the same time, due to the high level of migration, we assume np_0 = 0 in order to generate a realistic demographic structure. So, the rate of newborns each year t equals 0%.

The mortality rate is measured by survival probability $\psi_{j,t}$, does not depend on class, and gradually decreases from 1 to 0 with rising cohort age, which was taken from data of Ptoukha Institute for Demography (2021). The number of households is determined as

$$N_{j,i,t} = \psi_{j,t} * N_{j-1,i,t-1}, \quad (4)$$

with $N_{1,i,t} = (1 + np_t) * N_{1,i,t-1}$.

In further model calculations, due to aggregate individual variables to economy-wide quantities, we define the normalized population size of a cohort of age j, class i, at time t using new aggregation method – cohort weights $M_{j,i,t}$ as

$$M_{j,i,t} = M_{j-1,i,t-1} * \frac{\psi_{j,t}}{(1+np_t)}, \quad (5)$$

with normalization $M_{1,i,t} = 1$.

In this model, variables np_t and $\psi_{j,t}$ are calibrated based on exogenous population projections, which allows for accurate simulation of the demographic scenarios of any configuration within the model.

Production sector

In the production sector, the factors of production, labor and capital, are used to produce goods. In both factor markets, there is perfect competition, i.e., wages and interest rates are set for enterprises. Gross wages (per unit of efficiency) are equal to the marginal product of labor in equilibrium, and the market interest rate is the difference between the marginal product of capital (i.e., after corporate tax deduction) and the rate of depreciation of capital.

At any time t, a representative firm hires labor and rents physical capital to produce a single good using a Cobb–Douglas technology. The production function thus reads:

$$Y_t = K_t^{\alpha} + L_t^{1-\alpha}, \quad (6)$$

where Y_t denotes output in each year t, K_t is physical capital, L_t denotes effective units of labor, α represents the share of physical capital in output. We assume a capital-income share in production of 30 per cent, i.e. $\alpha = 0.3$.

In the closed economy version of the model, we calculate rental cost of capital and labor:

$$r_t = \alpha * k_t^{\alpha-1} - \delta, \quad (7)$$
$$w_t = (1-\alpha) * k_t^{\alpha}, \quad (8)$$

where $k_t = \frac{K_t}{L_t}$ denotes capital intensity, r_t and w_t denote the rental rate of capital and the wage rate in each year t, respectively. The capital stock depreciates physically during the production process at rate $\delta = 0.05$ per year.

Household sector

As previously mentioned, household sector is measured by 80 representative cohorts that interact in an 'overlapping generations' structure representing each of the age groups. When entering the labor market, cohorts optimize their labor supply and their consumption-saving patterns over time. The household's optimization problem consists of choosing a profile of goods and leisure consumption over the life cycle that maximizes a constant elasticity of substitution inter-temporal utility function, subject to the lifetime budget constraint.

Households decide about how much to work, consume and save in the different periods of their life. They have to pay taxes with the following tax rates in year t: t_t^c, t_t^w, t_t^p and t_t^r – consumption, labor-income, payroll, and capital-income tax rates respectively. In reward for taxes, they receive pension benefits $pen_{jr,i,t}$ in $jr = (41{,}80)$ period of life. Households also have to decide how to split up their total time endowment of one unit between working time and leisure $l_{j,i,t}$. The remaining time after work is used for leisure consumption which now features in household utility. Leisure demand in each period of the life cycle strongly depends on the respective value of human capital $h_{i,j}$, which measures the value of the time endowment in terms of labor market productivity. Households' classes may work the same number of hours, but they may be differently productive, so that they earn a different wage per time unit. Whenever the wage a household earns in the labor market is very small, the household might want to consume more leisure than the actual time endowment. In order to guarantee that the time endowment is met, we calculate a so-called shadow wage $\mu_{j,i,t}$. The shadow wage is added to the regular wage of the household and calculated such that the household's optimal decision consists in consuming the household's total endowment of time as leisure. As this also means that the agent provides zero working hours to the market, the shadow wage is a fictitious wage that will never be paid to the household.

Households born in period t maximize the time-separable utility function, where future consumption is further discounted by the survival probabilities and working/leisure time preference:

$$maxU_{1,i,t} = \sum_{j=1}^{80} \beta^{j-1} * S_{j,t} * \frac{\left(c_{j,i,s}^{1-\frac{1}{\rho}} + v * l_{j,i,s}^{1-\frac{1}{\rho}}\right)^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}}{1-\frac{1}{\gamma}}, \quad (9)$$

with

$$S_{j,t} = \prod_{z=1}^{j} \psi_{z,t+z-1}, \quad (10)$$

where $s = t + j - 1$ and denotes a year in households individual life cycle track ($s = (1{,}80)$), z denotes the age of specific household's survival probability during individual life cycle ($z = (1{,}80)$), β denotes a time discount factor and equals 0.98, γ denotes the intertemporal elasticity of substitution between consumption in different years and equals 0.5, ρ defines the intratemporal elasticity of substitution between consumption and leisure and equals 0.7. The leisure preference parameter v is used to calibrate a realistic fraction of working time and equals 1.5.

So, households have to decide how much to consume $c_{j,i,t}$ and save $a_{j,i,t}$ in each period and how to split up their total time endowment of one unit between working time and leisure $l_{j,i,t}$. In this model, households know their survival probability, so they are able to plan at which point in time they wanted to exhaust all their savings. If they die earlier than the maximum age, they leave unintended bequests $beq_{j,i,t}$. These bequests are transferred to the surviving households at the twenty youngest cohorts at year t. Consequently, the annual budget constraint is now defined as the equality between personal consumption and personal income, taking into account savings for future periods:

$$s.t. \quad p_t * c_{j,i,t} = wn_{j,i,t} * \left(1 - l_{j,i,t}\right) + beq_{j,i,t} + pen_{j,i,t} + R_t * a_{j,i,t} - a_{j+1,i,t+1}, \tag{11}$$

where $a_{j,i,t}$ denotes household's savings of j cohort, i class in year t, $wn_{j,i,t} = \left(w_t * h_{i,j} + \mu_{j,i,t}\right) * (1 - t_t^w - t_t^p)$, $R_t = 1 + r_t * (1 - t_t^r)$, and $p_t = 1 + t_t^c$ define net wage rates of a j-year-old worker in year t, net interest rates, and consumer prices, respectively.

The individual optimization of (9) s.t. (11) yields the leisure demand which measures from 0 to 1 and calculates as:

$$l_{j,i,t} = \left(\frac{wn_{j,i,t}}{\nu * p_t}\right)^{-\rho} * c_{j,i,t}. \tag{12}$$

The assets of those who die during period t are distributed between surviving cohorts $j = (1,20)$. Therefore, if the survival rate $\psi_{j,t}$ at time t in age group j is less than one, then younger cohorts at time $t+1$ have more assets. The surviving cohort's income from personal bequests $beq_{j,i,t}$ can then be calculated as:

$$beq_{j,i,t} = \frac{\omega_j * BQ_{i,t}}{\sum_{j=1}^{20} \omega_j * M_{j,i,t}}, \tag{13}$$

where ω_j are exogenously specified as the rate of distribution of inheritance among the surviving cohorts $\sum_{j=1}^{20} \omega_j = 1$, and $BQ_{i,t}$ is total amount of bequests in economy in year t for income class i:

$$BQ_{i,t} = \sum_{i=1}^{3} \sum_{j=1}^{80} a_{j,i,t} * R_t * \frac{M_{j,i,t}}{\psi_{j,t}} * (1 - \psi_{j,t}). \tag{14}$$

Households of different ages may earn more or less per hour because of differences in human-capital endowments $h_{i,j}$. In the following, the human-capital profile $h_{i,j}$ is set exogenously by formula:

$$h_{i,j} = \frac{EXP(EA_i + EB_i * j + EC_i * j^2)}{EXP(EA_{i=2} + EB_{i=2} + EC_{i=2})}, \tag{15}$$

where EA_i = (1.0; 1.3; 1.9), EB_i = (0.045; 0.049; 0.062), EC_i = (-0.00122; -0.00125; -0.00139). Human-capital endowments of all classes gradually decrease after the peak, so $h_{1-3,80}$ = 0.

If, for a given wage level w_t, leisure demand $l_{j,i,t}$ exceeds the total time endowment of unity, we compute a shadow wage rate $\mu_{j,i,t}$ that reduces leisure demand exactly to the time endowment.

$$\mu_{j,i,t} = \frac{c_{j,i,t}^{\frac{1}{\rho}} * p_t * \nu}{1 - t_t^w - t_t^p} - w_t * h_{i,j}. \tag{16}$$

From (11) intertemporal budget constraint is now defined as:

$$W_{1,i,t} = \sum_{j=1}^{80} \left(wn_{j,i,s} + beq_{j,i,s} + pen_{j,i,s}\right) * \prod_{k=t+1}^{s} (R_k)^{-1} = \sum_{j=1}^{80} (p_s * c_{j,i,s}) * \prod_{k=t+1}^{s} (R_k)^{-1}. \tag{17}$$

Substituting (12) into the budget constraint equation (11) yields $c_{j,i,t}$ the consumption functions of the household of the cohort j, the class i in t year as:

$$c_{j,i,t} = \frac{vv_j}{vv_{j-1}} * \left(\beta^{j-1} * S_{j,t} * R_t * \frac{p_{t-1}}{p_t}\right)^{\gamma} * c_{1,i,t}, \tag{18}$$

where

$$vv_j = \left(1 + \nu^{\rho} * \left(\frac{wn_{j,i,t}}{p_t}\right)^{1-\rho}\right)^{\frac{\rho-\gamma}{1-\rho}}, \tag{19}$$

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Substituting (18) into the budget constraint (17) yields consumption in the first period of the life of a household $c_{1,i,t}$:

$$c_{1,i,t} = W_{1,\mathrm{i,t}} * \Gamma_{1,i,t}, \quad (20)$$

with

$$\Gamma_{1,i,t} = \frac{\upsilon\upsilon_{1,i,t}}{p_t} * \left[\sum_{j=1}^{80}(\beta^{j-1} * S_{j,t})^{\gamma} * \left[\frac{p_s}{p_t} * \prod_{k=t+1}^{s}(R_k)^{-1}\right]^{1-\gamma} * \upsilon\upsilon_{j,i,s}^{\frac{1-\gamma}{\rho-\gamma}}\right]^{-1}. \quad (21)$$

Now we compute C_t - households' aggregate consumption:

$$C_t = \sum_{i=1}^{3}\sum_{j=1}^{80} c_{j,i,t} * M_{j,i,t}. \quad (22)$$

As initial savings $a_{1,i,t}$ of youngest cohorts are zero, the savings functions of $j = (2{,}80)$ cohorts can be derived by plugging the consumption functions into the budget constraint, while households' aggregate savings A_t:

$$A_t = \sum_{i=1}^{3}\sum_{j=1}^{80} a_{j,i,t} * \frac{M_{j,i,t}}{\psi_{j,t}}. \quad (23)$$

So, in this sector, in each cohort j, class i and every year t we determine balance between how much households receive income, consume and save in condition of maximizing the utility function.

Government sector

The government sector model consists of the country's aggregate consolidated budget and the state pension insurance fund. The state generates revenues through new public debt and taxes. This income is used to service interest expenses and government expenditures, like pension benefits $pen_{j,i,t}$ and public consumption G_t. Per capita spending on public goods is constant and age dependent. The share of the debt level in the national product is kept constant by new debt. The amount of public good is computed depending on the population structure, i.e.

$$G_t = gy * N_t. \quad (24)$$

where gy represent the per capita coefficients for public good provision. In order to to generate a realistic
government share in GDP, we set per capita public goods consumption for each cohort $gy = 0.125$.

Pension benefits are calculated for each household only once in year t, when it reaches the age of jr, and then the pension is unchanged for this individual household. We assume that in each period t the level of pension benefits is computed as a fraction κ_t of the household's individual average wage $AW_{i,t}$ for all working period before getting jr-age:

$$pen_{jr,i,t} = \kappa * AW_{i,t}, \quad (25)$$

where $\kappa_t = 0.3$ (calculated based on Fig.1), and

$$AW_{i,t} = \frac{\sum_{j=1}^{jr-1} w_s * h_{j,s} * (1 - l_{j,i,s})}{jr - 1}, \quad (26)$$

where $s = t + j - jr$ denotes a specific year of the working age of the household. The payroll tax rate as contributions from workers to finance benefit payments to retirees is calculated as:

$$t_t^p = \frac{PB_t}{w_t * L_t}, \quad (27)$$

where

$$PB_t = \sum_{j=jr}^{80} \sum_{i=1}^{3} pen_{j,i,t} * M_{j,i,t}. \quad (28)$$

and means the total amount of pensions in the economy in year t.

Households contribute to public expenditure in the form of taxes, which forms the state budget or public consumption G_t. In our model, we also take into account that a part of public expenditures will be financed with public debt. Thus, the total fund from which all public expenditures are financed is as follows:

$$TAX + (1 + np_t) * B_{t+1} = (1 + r_t) * B_t + G_t, \quad (29)$$

$$TAX = t_t^c * C_t + t_t^w * w_t * L_t + t_t^r * r_t * A_t, \quad (30)$$

where B_t is public debt in period t. In the simulations presented in this paper, taking into account the public debt, public goods and tax revenues from formulas (29) and (30), we determine consumption tax rates t_t^c as endogenous policy variable that adjusts in every period to achieve a balanced government.

Market and aggregation equilibrium conditions

For a market equilibrium, the goods market and factor markets need to be balanced. Perfect competition is assumed in all markets. The equilibrium condition in the goods market requires that output be equal to aggregate absorption, which is the sum of aggregate consumption, investment and government spending:

$$Y_t = C_t + I_t + G_t. \quad (31)$$

The law of emergence of investments is – the units of capital accumulated up to period t must equal the units of capital demanded by the representative firm in that period:

$$I_t = (1 + np_{t+1}) * K_{t+1} - (1 - \delta) * K_t. \quad (32)$$

Labor market clearing requires that the demand for labor be equal to the supply. Similarly, the units of capital accumulated up to period t must equal the units of capital demanded by the representative firm in that period. The capital stock K_t and labor supply L_t are exogenous at the beginning of model calculations. After calculations go through demographic structure, labor supply L_t is calculated as endogenous.

$$L_t = \sum_{i=1}^{3} \sum_{j=1}^{80} h_{i,j} * (1 - l_{j,i,t}) * M_{j,i,t}. \quad (33)$$

In case of closed economy, capital stock K_t is derived from the capital market and can be found from:

$$A_t = K_t + B_t. \quad (34)$$

In this case, the rental rate of capital r_t is calculated by formula (7) and changes for each subsequent period t. Thus, equilibrium in the financial market requires total stock of private wealth A_t to be equal to the value of the total stock of capital K_t accumulated and amount of public debt B_t in period t.

Welfare effect

In order to determine the level of welfare effect, using formula (9), we first calculate the utility function for age $j = 1$ to compare the well-being of cohorts of each class i that are just entering the labor market every period t.

Next, we introduce a welfare measure which allows us to compare and interpret the welfare consequences of a certain policy reform for different cohorts living along the transition path and in the new long-run equilibrium. Thus, we will compare the level of utility of the cohorts that made decisions in the baseline scenario and those that did so after the economic reforms to determine the income equivalent variation. Since it was introduced by Sir John R. Hicks—the Hicksian equivalent variation (HEV), we specify:

$$\Delta U_{j,i,t} = \left(\left(\frac{U_{j,i,t}^{r,s}}{U_{j,i,t}^{b,s}}\right)^{\frac{1}{1-\frac{1}{\gamma}}} - 1 \right) * 100\%, \quad (35)$$

where $U_{j,i,t}^{bs}$ - utility level of the cohorts living in baseline scenario, $U_{j,i,t}^{rs}$ - utility level of the cohorts living reform scenario.

So, $\Delta U_{j,i,t}$ will introduce the change in welfare expressed as a percentage of initial resources of a cohort as the main indicator of intergenerational welfare consequences of a reform. Typically, some cohorts will gain from the reform while others will lose.

Calibration

The model is calibrated using 2021 data ($t_1 = 2021$) for Ukraine. Exogenous model data, such as the number of household cohorts, population class ratio, labour intensity in each class, life expectancy, survival rate in each cohort, pension age, annual population growth, are taken from the State Statistics Service of Ukraine (2021) and Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine (2021). Population projections are used for the calibration of the fertility and survival rates used in the model. In the baseline scenario, we expect life expectancy to increase during 2021-2060 by gradually increasing $\psi_{j,t}$. Other model parameters, like household consumption and savings rates, tax rates, pension contribution, retirement benefits, inheritance, working hours of each cohort, are simulated.

The data on public finances and GDP components are taken from the State Statistics Service of Ukraine (2021). The effective labour income, capital and consumption tax rates are calculated from the corresponding government revenue categories and calibrated tax bases. Data on total amount of pensions are taken from the Pension Fund of Ukraine (2021).

First, the baseline scenario is calibrated, which reflects the real situation in Ukraine's economy in 2021. The next step is to simulate the model for 40 years, taking into account the conditions of the baseline scenario and the proposed reforms: increase in the capital-income tax rate; partial financing of pensions from the budget; increase in the state pension age. Next, we compare the effect of the proposed reforms with the baseline scenario.

Baseline scenario

This section describes real demographic and macroeconomic indicators of the base year and their subsequent transition for the next 40 years without reforms. Table 2 shows official and simulated population dynamic. In the base year 2021, official life expectancy is 72,3 years. In the following years, the life span of households increases up to 78,1 years in 2060 and remains constant thereafter. As shown in the life expectancy dynamic, the chosen in model structure of survival probability $\psi_{j,t}$ replicates the official life expectancy quite well. In the population dynamics in the base year 2021, the model uses the exact structure of the population by cohorts according to official data, with a population of just over 41 million people. In the long run, population size approaches 31.1 million, while the official forecast envisages a decline in population to 32.4 million people. In model is assumed the following population growth: $np_t = 0$. The real share of newborns each year during 2000-2020 averaged 1% of the total population, but the constant level of labour migration prevents this from affecting the population growth rate.

In the long run, this structure provides for an increase in the number of pensioners up to 35.8% of the total population by official forecasts, while the model simulates this figure at 31.8%. The model also matches the official forecasts of base year dependency ratios - 41%. Transition path of the model indicates a significant increase in dependency ratios in 40 years by official data - 76% and model - 66%.

Table 2: Official and simulated population dynamics

Year	2021	2025	2030		2035	2040	2045	2050	2055	2060
Life expectancy										
Model	72.3	73.3	74.3		75.2	76.0	76.6	77.2	77.7	78.1
Official[b]	72.3[a]	72.9	73.7		74.4	75.2	75.9	76.7	77.4	78.1
Population										
Model	41.3	39.9	38.0		36.1	34.7	33.7	32.8	31.9	31.1
Official[b]	41.6[a]	40.8	39.8		38.9	38.0	36.9	35.4	33.9	32.4
Age groups - Model										
0-20	20.0	20.1	19.6		18.4	17.9	18.4	18.9	19.5	20.0
21-40	28.6	26.5	23.3		21.7	21.7	22.3	22.9	23.5	24.2
41-60	28.4	29.4	32.6		34.3	33.5	30.5	26.6	24.4	24.1
61-100	23.1	24.0	24.5		25.6	26.8	28.8	31.5	32.7	31.8
Age groups – Official[b]										
0-20	20.8[a]	20.8	19.7		17.7	16.7	17.0	17.2	17.3	17.0
21-40	28.3[a]	26.0	23.5		23.3	23.7	23.8	22.6	20.5	19.6
41-60	28.1[a]	28.8	31.4		32.2	31.1	28.5	26.3	26.6	27.6
61-100	22.9[a]	24.4	25.5		26.8	28.4	30.8	33.9	35.6	35.8
Dependency ratio										
Model	0.41	0.43	0.44		0.46	0.49	0.54	0.64	0.68	0.66
Official[b]	0.41[a]	0.45	0.46		0.48	0.52	0.59	0.69	0.76	0.76
a State Statistics Service of Ukraine (2021)										
b Ptoukha Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine (2021)										

Table 3 reports the structure of the model's initial equilibrium and compares it with the respective actual figures for 2021, as well as changes in some important macroeconomic variables for the next 40 years. All in all, the model represents the basic economic and fiscal structure of Ukraine quite well. Since the model is simulated as a closed economy, the interest rate is endogenous. The path of wages and interest rates results directly from the changes in employment and the capital stock. On the government side, labor-income tax t^w and capital-income tax t^r rates are exogenously fixed at 15 and 5 % respectively. Due to the social benefits of t^w, the official rate of 18% at the macroeconomic level may correspond to 15%. So, two tax rates are simulated in baseline scenario - t^c and t^p. The official VAT rate is 20%, and the excise tax and customs duty add another 3%. The official payroll tax rate of 18.5% is often applied in the shadow economy conditions and macroeconomicly may correspond to 11%.

The model simulates the capital stock share in the economy K_t/Y_t at 3.59 in initial year, while its real level in 2021 is between 2.03 and 5.30 (2.03 - value of fixed assets of enterprises, 5.30 - value of fixed assets of enterprises and industrial and private housing stock). The share of consumption in GDP C_t/Y_t is simulated at 62% in 2021, while the real data is 66%. This difference is due to partial shadow incomes of households. The share of investments in GDP I_t/Y_t is simulated at 15%, but according to official statistics it is 12%, which is due to only partial utilization of investments planned for the year.

Table 3: Baseline behavioral scenario of households

Year	2021	2025	2030	2035	2040	2045	2050	2055	2060
t_t^c	0.23 (0.23)[a]	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
t_t^p	0.11 (0.11)[a]	0.11	0.12	0.13	0.14	0.16	0.18	0.19	0.19
w_t	1.02	1.02	1.03	1.03	1.04	1.05	1.05	1.03	1.01
r_t	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
L_t/L_1	1.00	0.96	0.91	0.86	0.81	0.75	0.70	0.67	0.66
K_t/Y_t	3.59 (2.03-5.30)[a]	3.61	3.65	3.71	3.77	3.81	3.80	3.69	3.51
C_t/Y_t	0.62 (0.66)[a]	0.61	0.61	0.60	0.60	0.61	0.61	0.61	0.61
I_t/Y_t	0.15 (0.12)[a]	0.15	0.16	0.16	0.15	0.14	0.13	0.12	0.12
BQ_t/Y_t	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.02
G_t/Y_t	0.24 (0.24)[a]	0.24	0.24	0.24	0.25	0.25	0.26	0.27	0.27
VAT_t/Y_t	0.14 (0.14)[a]	0.14	0.14	0.15	0.15	0.16	0.17	0.18	0.18
WT_t/Y_t	0.11 (0.09)[a]	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
PEN_t/Y_t	0.07 (0.06)[a]	0.08	0.08	0.09	0.10	0.11	0.13	0.14	0.13
IRT_t/Y_t	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
$YperP$	0.53	0.53	0.53	0.52	0.51	0.49	0.47	0.46	0.46
a Pension Fund of Ukraine (2021)									

The share of the government sector in GDP in the initial year of the simulation model replicates the officially established level and equals 24%. The model considers important features such as government debt as B_t = 46.5 % of GDP and it is fixed for all periods. So, tax revenues also have to cover interest payments on public debt. The share of consumption tax VAT_t in the economy is 14% officially in initial year. The share of labor-income tax WT_t officially is 9% and simulated 11% in year 2021. The difference in the initial year between the official and simulated share means that households, in addition to labor-income tax, pay small public fees, which are not included in the official component. The share of pension payments PEN_t in the economy is 7% in 2021. Official share of pensions in GDP is 6%, and doesn't include some public services for pensioners that were mentioned. The share of capital-income tax IRT_t = 1% is exogenously constant. Bequests BQ_t are received by 21-40 years old population and their share in the state economy is decreasing due to the increase in the life expectancy of the population.

Population aging induces a change in the population structure. This increases the share of pensioners and reduces the share of working-age cohorts in the total population. For example, index L_t/L_1 in year 2060 equals 0.66, which means that labor supply in 2060 is only 66% of initial year 2021. With respect to the economic consequences, we have to identify the effects on public budgets and on factor prices. Thus, the ageing of the population reduces the labour supply L_t and at the same time increases the payroll tax t_t^p to finance pensions from 11 to 19% over the next 40 years. The share of pension payments PEN_t in the economy is simulated from 7% to 13% in long run. The increase in pension contributions reduces the savings A_t rate of the households, and therefore reduces capital stock K_t in the economy.

Due to the decrease in capital stock, the level of wages in the economy decreases, which leads to lower incomes. Accordingly, wages tax revenues WT_t to the budget decline, which is balanced by an increase in the consumption tax rate t_t^c from 23 to 30% and an increase in the share of VAT in GDP from 14 to 18 % over the long run period, which generally reduces the demand for consumption by the population. The higher consumption taxation level reduces the savings rate of the households harder. All these factors lead to a decline in GDP per capita $YperP$ starting in 2030 and throughout the period. The government sector from 24 % of GDP in initial year increases to 27 % in the long run due to the fixed number of public goods per capita with GDP per capita slowly decreasing. The share of capital in the economy K_t/Y_t gradually increases until 2050 and rapidly declines over the next 10 years. As already noted, capital stock is declining, but GDP is declining faster.

Thus, population aging leads to increase in future payroll tax and consumption tax rates. That reduces individual savings, capital accumulation and future wages, while interest rates increase. The reduction of the wage hurts all working-age cohorts while the interest rate increase is beneficial for pensioners. Consequently, future cohorts experience a GDP per person reduction. Thus, population aging without reform regulation leads to future cohorts experiencing higher taxes and lower economic growth.

Reform 1 scenario - increase in the capital-income tax rate

In this section, we consider the reform strategy for raising the capital-income tax t^r rates from 5% to 15% and fix it for the next model simulation. All other exogenous parameters from baseline scenario are not changed. Table 4 reports the structure of the model's reform equilibrium for the next 40 years. We will now compare the results of the new model simulation with the results of the baseline scenario.

Table 4: Reform 1 behavioral scenario of households – increase t_t^r to 15%

Year	2021	2025	2030	2035	2040	2045	2050	2055	2060
t_t^c	0.21	0.21	0.22	0.23	0.24	0.25	0.27	0.28	0.28
w_t	1.02	1.02	1.02	1.02	1.03	1.03	1.03	1.02	0.99
L_t/L_1	1.00	0.96	0.92	0.87	0.81	0.76	0.71	0.67	0.66
K_t/Y_t	3.61	3.57	3.57	3.61	3.65	3.68	3.67	3.55	3.37
C_t/Y_t	0.63	0.62	0.61	0.61	0.61	0.61	0.61	0.61	0.61
I_t/Y_t	0.13	0.14	0.15	0.15	0.14	0.13	0.12	0.11	0.11
BQ_t/Y_t	0.05	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02
G_t/Y_t	0.24	0.24	0.24	0.24	0.25	0.26	0.27	0.28	0.28
VAT_t/Y_t	0.13	0.13	0.13	0.14	0.14	0.15	0.16	0.17	0.17
$YperP$	0.53	0.53	0.52	0.51	0.50	0.49	0.47	0.45	0.45

The change in capital-income tax t^r rate leads to a slight reduction in the consumption tax t^c rate from 30% to 28% in long run period. Accordingly, the share VAT_t/Y_t will decrease from 18% to 17%, while the behavior of household consumption in relation to economic changes C_t/Y_t will remain the same. The payroll tax t_t^p rate and share PEN_t/Y_t are not influenced by the reform.

The level of wages w_t decreases (from 1.1 to 0.99 in long run), which leads to a slight increase in the supply of working hours and in labour supply (index L_t/L_1 in period 2030-2050 is higher than in baseline scenario). But due to the tax t^r rate increase, there is a sharp reduction in households savings A_t. The attendance of capital in the economy K_t/Y_t gradually cutting down during all simulated period equals 3.37 comparing to baseline scenario 3.51 in 2060. This happens due to the high sensitivity of capital stock to the capital-income tax policy which reduces individual savings. As a result, this leads to a decrease in GDP per capita $YperP$. This, accordingly, slightly reduces the presence of investment I_t/Y_t and bequest BQ_t/Y_t in the economy.

Thus, raising the capital-income tax leads to decrease in wages and household savings. As a result, households work more with lower income effects. The presence of capital stock in the economy is also significantly reduced in the long run.

Reform 2 scenario - partial financing of pensions from the budget

In this section, we consider the reform strategy for financing pension payments partially from the budget. The payroll tax rate is fixed now at the level of 2021 t_t^p = 11% for the whole period. All other exogenous parameters remain the same as in the baseline scenario. As t^w, t^r and t_t^p are fixed now, the budget will be balanced by changes in the consumption tax t_t^c rate in the long run. Table 5 reports the structure of the model's reform equilibrium for the next 40 years to compare with the baseline scenario.

Table 5: Reform 2 behavioral scenario of households - t_t^p fixed on 11%

Year	2021	2025	2030	2035	2040	2045	2050	2055	2060
t_t^c	0.23	0.24	0.26	0.27	0.29	0.32	0.36	0.38	0.38
pentax	0.00	0.07	0.12	0.17	0.23	0.32	0.40	0.44	0.43
w_t	1.02	1.02	1.03	1.03	1.04	1.04	1.04	1.03	1.02
r_t	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
L_t/L_1	1.00	0.97	0.92	0.87	0.81	0.76	0.72	0.69	0.67
K_t/Y_t	3.60	3.60	3.64	3.70	3.75	3.77	3.75	3.68	3.58
C_t/Y_t	0.62	0.61	0.61	0.60	0.60	0.60	0.60	0.60	0.60
I_t/Y_t	0.14	0.15	0.16	0.15	0.15	0.14	0.14	0.14	0.14
BQ_t/Y_t	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03
G_t/Y_t	0.24	0.24	0.24	0.24	0.25	0.25	0.26	0.26	0.26
VAT_t/Y_t	0.14	0.15	0.15	0.16	0.18	0.20	0.22	0.23	0.23
PEN_t/Y_t	0.07	0.08	0.08	0.09	0.10	0.11	0.12	0.13	0.13
Y*per*P	0.53	0.53	0.53	0.52	0.51	0.49	0.48	0.47	0.47

Pension payments are now financed from the budget ($pentax$) in shares from 7% to 43% in 2025 and 2060. This reform leads to a significant increase in the consumption tax t^c rate from 30% to 38% in long run period, as now it balances public goods supply G_t. Accordingly, the share VAT_t/Y_t will raise from 18% to 23%, which, accordingly, will slightly reduce the households' consumption in relation to economic changes C_t/Y_t. The share of PEN_t/Y_t and BQ_t/Y_t are not really influenced by the reform. Major changes occur in labour supply, consumption and household savings, which differs in periods.

As for labor supply L_t, due to the fixed t_t^w and t_t^p, it is higher than in the baseline scenario throughout the period. Labour supply growth and restrained consumption increase the upward trend in savings A_t, which has a corresponding impact on the capital stock K_t, wages w_t and GDP growth. These changes also have a positive impact on the investment processes I_t/Y_t in the economy.

Thus, partial financing of pensions from the state budget in the long run leads to higher prices and restrained consumption, while households increase their business activity due to stable income taxes, leading to improved economic growth compared to the baseline scenario.

Reform 3 scenario - increase in the state pension age

In this section, we consider the reform strategy for raising the retirement age (with other exogenous parameters same as in the baseline scenario). For the next model simulation, we assume that the retirement age will be raised from 60 to 63 years. Since such a dramatic change requires a smooth transition, we assume that the reform will start 10 years after the initial analysis period and is implemented in stages. Starting in 2030, the retirement age will be increased by one year with a 5-year interval and will reach the age of 63 in 2040 and remain unchanged thereafter.

The pension reform induces a change in the population structure. This reduces the share of pensioners and increases the share of working-age cohorts in the total population. Table 6 reports the changes in some important macroeconomic variables after the year of reform starting 2030. The change in the age structure of the population also increases the labour force L_t (index L_t/L_1 in period 2030-2055 is higher than in baseline scenario), since households work more in middle age when their human capital endowment reaches a peak. After year 2040, it is assumed that the same number of households enter the labour force each year. At the same time, the VAT t_t^c rate and pension contributions t_t^p are being reduced from 30% to 28% and from 19% to 16% respectively in long run. It happens due to a significant decline in pension payments PEN_t and an increase in the share of wage-income tax revenues WT_t with reduction of consumption tax VAT_t revenues in the budget. Increase in labour supply L_t influenced consumption C_t and saving A_t to grow, which has a corresponding impact on capital stock K_t, GDP and wages w_t growth in the long run. Consumption C_t/Y_t and bequest BQ_t/Y_t relative to GDP remain at the same level due to the simultaneous growth of consumption capacity, inheritance and income in the economy. Investment processes I_t/Y_t in the economy from 2040 have positive changes.

Table 6: Reform 3 behavioral scenario of households - increase of pension age

Year	2021	2025	2030	2035	2040	2045	2050	2055	2060
t_t^c	0.23	0.23	0.24	0.24	0.25	0.26	0.27	0.28	0.28
t_t^p	0.11	0.11	0.11	0.11	0.11	0.12	0.14	0.15	0.16
w_t	1.02	1.02	1.03	1.03	1.04	1.05	1.05	1.04	1.02
r_t	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
L_t/L_1	1.00	0.96	0.92	0.87	0.82	0.77	0.72	0.68	0.66
K_t/Y_t	3.59	3.61	3.64	3.69	3.75	3.81	3.83	3.76	3.62
C_t/Y_t	0.62	0.61	0.60	0.60	0.60	0.60	0.61	0.61	0.61
I_t/Y_t	0.15	0.16	0.16	0.16	0.16	0.15	0.14	0.13	0.13
G_t/Y_t	0.24	0.24	0.24	0.24	0.24	0.25	0.26	0.26	0.27
VAT_t/Y_t	0.14	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17
PEN_t/Y_t	0.07	0.08	0.08	0.08	0.08	0.08	0.10	0.11	0.11
Y*per*P	0.53	0.53	0.53	0.53	0.52	0.50	0.49	0.47	0.47

Thus, raising the retirement age in the long run leads to a reduction in the tax burden, increased labour supply, consumption and household savings. This, in turn, leads to GDP growth, increased capital presence in the economy, and higher wages.

Reform 2 and 3 simultaneous implementation – behavioral scenario of households

In this section, we consider the combination of two reforms together - financing of pension payments partially from the budget and raising the retirement age from 60 to 63 years from 2030, because they have had a positive impact on the well-being of most cohorts. Table 7 reports the structure of the model's reforms equilibrium for the next 40 years. Now we compare it with the baseline scenario.

Table 7: Simultaneous implementation of reforms 2 and 3 - behavioral scenario of households

Year	2021	2025	2030	2035	2040	2045	2050	2055	2060
t_t^c	0.23	0.24	0.24	0.25	0.26	0.28	0.31	0.33	0.34
pentax	0.00	0.07	0.06	0.05	0.05	0.12	0.23	0.31	0.32
w_t	1.02	1.02	1.03	1.04	1.04	1.05	1.04	1.04	1.02
L_t/L_1	1.00	0.97	0.92	0.87	0.82	0.77	0.73	0.69	0.68
K_t/Y_t	3.60	3.60	3.65	3.71	3.77	3.80	3.79	3.72	3.63
C_t/Y_t	0.62	0.61	0.60	0.60	0.60	0.61	0.61	0.60	0.60
I_t/Y_t	0.15	0.16	0.16	0.16	0.15	0.14	0.14	0.14	0.14
G_t/Y_t	0.24	0.23	0.24	0.24	0.24	0.25	0.26	0.26	0.26
VAT_t/Y_t	0.14	0.15	0.15	0.15	0.15	0.17	0.19	0.20	0.20
PEN_t/Y_t	0.07	0.08	0.08	0.08	0.08	0.08	0.10	0.11	0.11
Y*per*P	0.53	0.53	0.53	0.53	0.52	0.50	0.49	0.48	0.48

All taxes except the consumption tax are now fixed: t^w = 15%, t^r = 5%, t^p = 11%. Pension payments are now financed from the budget in shares from 7% to 32% in 2025 and 2060. These two reforms, first of all, lead to increase in the consumption tax t^c rate from 30% to 34% in long run period, and increase in labour supply L_t compared to the baseline scenario. These changes will lead to an increase in VAT_t/Y_t and a decrease in PEN_t/Y_t in the economy.

The increase in the VAT rate t^c resulted in higher prices and, consequently, lower consumption C_t/Y_t. At the same time, household incomes increased due to business activity L_t (labor supply is higher relative to the baseline scenario), which made it possible to save A_t and accumulate more capital K_t. Now K_t/Y_t experiences constant growth which also affects wages w_t. These changes also have a positive impact on GDP per person $YperP$ from 2035 and investment processes I_t/Y_t in the economy from 2050.

Thus, partial financing of pensions from the state budget and raising the retirement age due to a reduction in the tax burden on wages and increased business activity of households lead to higher household wages and savings, capital intensity and GDP growth in the long run.

Welfare effects of the reforms

In this section, we analyze how the proposed reforms will affect the welfare of the population in the long run and by income class. Figure 2 and Table 8 present the well-being data of the cohorts, taking into account their birth year; so, there are shown the cohorts that have already been born and future cohorts within 100 years.

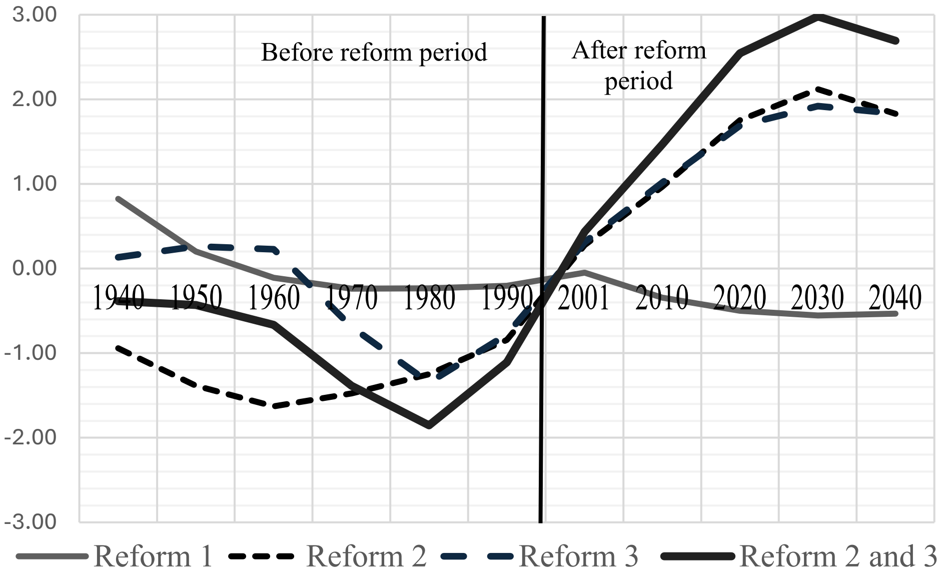

Fig 2. Welfare effects of the reforms (in % of lifetime resources)

Olga TOFANIUK, Journal of Eastern Europe Research in Business and Economics,
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Table 8: Welfare effects of the reforms by income classes

Birth year	Reform 1			Reform 2			Reform 3			Reform 2 and 3		
	Households income class			Households income class			Households income class			Households income class		
	I	II	III	I	II	III	I	II	III	I	II	III
1940	0.85	0.80	0.67	-0.93	-0.95	-1.02	0.15	0.12	0.03	-0.36	-0.41	-0.54
1950	0.21	0.19	0.14	-1.40	-1.37	-1.33	0.28	0.24	0.17	-0.42	-0.44	-0.50
1960	-0.11	-0.11	-0.11	-1.66	-1.60	-1.46	0.24	0.22	0.15	-0.67	-0.66	-0.65
1970	-0.25	-0.23	-0.17	-1.52	-1.43	-1.25	-0.71	-0.67	-0.58	-1.43	-1.34	-1.15
1980	-0.25	-0.22	-0.14	-1.30	-1.20	-0.99	-1.40	-1.30	-1.09	-1.93	-1.78	-1.47
1990	-0.22	-0.19	-0.12	-0.89	-0.80	-0.58	-0.82	-0.74	-0.56	-1.17	-1.05	-0.78
2001	-0.06	-0.04	0.00	0.25	0.30	0.43	0.30	0.32	0.40	0.41	0.46	0.59
2010	-0.36	-0.33	-0.26	0.95	0.98	1.09	1.02	1.01	1.02	1.46	1.47	1.55
2020	-0.52	-0.48	-0.39	1.76	1.74	1.75	1.71	1.67	1.59	2.57	2.52	2.46
2030	-0.58	-0.53	-0.43	2.15	2.09	1.97	1.95	1.89	1.78	3.03	2.93	2.74
2040	-0.56	-0.51	-0.41	1.86	1.80	1.69	1.86	1.81	1.72	2.74	2.65	2.47
I-low-income class (57.3%), II - middle class (38.7%), III - rich class (4.0%).												

From the first reform, with an increase in the capital-income tax, only "old" cohorts will benefit and all others will lose. This can be explained by the fact that households aged 70-80 consume more and save less. Thus, a slight reduction in the VAT rate will have a positive impact on their welfare. In terms of classes, the wealthy class aged 70-80 receives less welfare than middle and poor due to the greater opportunity to earn capital gains, but now with more taxation. All born after 1960 are losing in well-being, and this effect increases in the long run. As already mentioned, less capital intensity in economy leads to less wages which hurts working cohorts. Less savings and lower wages hurt low-income and middle classes harder. The wealthier class loses less due to receiving more income from wages and bequest.

From the second reform, with partial financing of pensions from the state budget, cohorts aged 30-80 will lose. Those cohorts which already pensioners (born in 1940-1960) at the time of the reform due to rising prices have less ability to consume with same income. . Working households (born in 1970-1990) lose as, by the time they retire, they will have almost the same income with the VAT rate increase; they will have to work more to consume, at the same level, having limited time to save for their 'old age' under these conditions. Younger and future cohorts (born after 2000) benefit from welfare gains, and this effect increases in the long run. Future wage growth with flat wage-income tax and pension contributions have a positive impact on their consumption and savings capacity. The wealthier cohorts will benefit slower than the poorer as significant rise in VAT rate influences their consumption harder.

From the third reform, with raising the retirement age, only cohorts born in 1970-1990 lose, all other cohorts increase welfare. The cohorts born in 1940-1960 are already retired and will not feel the impact of the age reform and are able to increase their consumption with lower VAT rate. The cohorts born in 1970-1990 will be at the age of 40-60 in the year the reform starts and will face all its negative effects. They will be forced to work more years without being able to save enough for their old age, as higher income and lower taxation effects of the reform start from 2050. Younger and future cohorts born 2001-2040 will experience a marked increase in well-being. This is due to sufficient time to adapt to the reform, higher wages, the possibility of saving during working age, and low taxes relative to the baseline scenario. For low-income cohorts, those born after 2020, the reform will bring more positive changes. By this time, the tax burden will have already been significantly reduced with wages rising and as a result the ability to save and consume more.

From the simultaneous implementation of reforms 2 and 3 , all the cohorts that entered the labour market before the reforms and pensioners will lose out. The cohorts that are already pensioners will lose out due to the expected increase in VAT, which will affect their consumption, and this effect will affect wealthier cohorts more. The working cohorts will choose to work fewer hours due to the expected reform of the retirement age and the estimated reduction in the taxation of income by pension contributions. This will lead to a decrease in their income in 2021, with poorer cohorts losing more due to the lower rate of pay for their work compared to wealthier cohorts. Younger and future cohorts benefit from welfare gains. The reforms allow them to earn, consume and save more compared to the baseline scenario. Starting from 2020 birth year, due to the gradual increase in the VAT rate and the higher consumption of the wealthier cohorts, they will benefit more slowly than the lower income ones.

Concluding remarks and future research

In this paper, we simulated and evaluated different scenarios for the Ukrainian pension and fiscal system. The main focus is on modeling various demographic scenarios and the resulting implications for the overall economic and fiscal development.

The three main findings of our analysis are as follows. First, performed reforms redistribute towards future generations at the cost of currently living older generations. While this is hardly surprising, the extent of the intergenerational redistribution differs quite significantly. In addition, the redistribution of wealth also occurs between classes of cohorts, which affects their motivation to increase or decrease their working hours, leisure, consumption, and savings. Second, the reform to reduce the burden on the Pension Fund through lump-sum pension payments from the state budget redistributes the burden of accumulating future pension payments from employers to consumers of goods and services. This increases labor supply and household incomes, which, combined with restrained consumption, leads to higher savings and, consequently, to faster economic growth with higher wages. Third, a rise in the standard starting age for receiving pension benefits enhances individual welfare. Possible reason for this is that higher employment rate for elderly individuals reduces public pensions and stimulates individual savings, which promotes capital formation and increases wage rates.

In continuing the development of the simulation model, we are going to estimate demographic transition with effects of current destruction of Ukrainian capital stock and further after war adjustment by foreign capital support. Thus, we expect the following possible effects of the reforms: how the foreign capital injections in support of Ukraine's infrastructure, science and economy will affect tax rates, pension payments, households' consumption, savings intensity, labour supply in the economy of a recovering state. Such a calculation will make it possible to simulate the state of the Ukrainian pension system and economy in the future, taking into account the effects of the war and the various forms of support for the EU economies in the form of: capital, scientific and innovative development, information support, integration mechanisms, open policy dialogue and other privileges. These calculations are important as Ukraine emerges from its war crisis and heads towards EU integration.

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