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Redistribution in Pension Systems:
Evidence from Hungary and Policy Implications

Abstract

Population aging, driven by rising life expectancy, is putting increasing pressure on the long-term sustainability of public pay-as-you-go pension schemes worldwide, leading many countries to consider or implement reforms. While increasing the statutory retirement age is often presented as the most direct response, it is politically contentious and can intensify generational and social inequalities that already challenge actuarial fairness. Such inequities reflect not only differences in lifetime earnings but also systematic disparities in life expectancy across social groups.

This paper examines redistribution in public old-age pension systems across regions, genders, and birth cohorts, focusing on inequalities in expected returns and on policy options to mitigate them while maintaining sustainability. We develop a comprehensive cash-flow model that combines regional mortality projections with

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macroeconomic assumptions, and we quantify redistribution by comparing expected real internal rates of return on contributions across groups.

The Hungarian pension system is used as an illustration, based on cohorts born between 1970 and 1985. The results suggest substantial heterogeneity in expected returns: representative participants’ expected real internal rates of return range from 1.1% to 3.5%, with women receiving higher returns than men. Despite having the highest earnings and life expectancy, Central Hungary exhibits the lowest returns, and younger cohorts are projected to attain higher returns than older ones. These patterns indicate structural redistribution within the system.

The paper contributes to the literature by showing how integrated cash-flow modeling can reveal otherwise hidden inequalities and by discussing policy strategies to address them. While the numerical findings are specific to Hungary, the proposed methodology is broadly applicable to pension policy design in other aging societies.

JEL Classification: *D63; H23; H55; H75*

Keywords: *pensions; inequality; retirement; redistribution; public policy*

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The raw data supporting the conclusion of this article will be made available by the authors upon request by email to the primary author.

Redistribution in Pension Systems:
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Abstract

Population aging and rising life expectancy are increasing pressure on the sustainability of public pay-as-you-go pension systems while raising concerns about redistribution and actuarial fairness. This paper examines differences in expected pension returns across regions, genders, and birth cohorts using Hungary as a case study. We develop a cash-flow model that combines regional mortality projections with macroeconomic assumptions and measure redistribution through expected real internal rates of return on pension contributions. Applying the model to cohorts born between 1970 and 1985, we find substantial heterogeneity in returns, with IRRs ranging from 1.1% to 3.5%. Women consistently achieve higher returns than men. Central Hungary exhibits the lowest returns despite having the highest earnings and life expectancy, and younger cohorts are projected to attain higher returns than older ones. These findings reveal structural redistribution within the pension system. We discuss policy implications and potential reform options, including retirement-age rules, contribution structures, and benefit indexation. The proposed methodology provides a transferable framework for evaluating redistribution and supporting evidence-based pension reform in aging societies.

JEL Classification: *D63; H23; H55; H75*

Keywords: *pensions; inequality; retirement; redistribution; public policy*

Introduction

The sustainability and fairness of public pension systems have become critical concerns amid rising life expectancy and population aging. These demographic trends put pressure on pay-as-you-go (PAYG) schemes, which dominate in Europe and other regions. Beyond the financial strain, they also raise questions of fairness, since pension outcomes differ across social groups in ways that can undermine intergenerational equity and public trust. Understanding these redistributive patterns is essential for designing reforms that are both sustainable and socially acceptable.

While there is extensive literature on pension reform and sustainability, comparatively little attention has been given to redistribution patterns within pension systems when examined simultaneously across regions, genders, and cohorts. Most existing studies treat these dimensions in isolation, focusing on gender gaps, regional disparities, or generational imbalances separately. This leaves a knowledge gap regarding how demographic heterogeneity and economic inequalities combine to generate implicit transfers in public pension systems.

The purpose of this paper is to fill this gap by developing a comprehensive cash-flow model that quantifies redistribution in terms of the expected internal rate of return (IRR) on contributions. Hungary is used as a case study not only because of the availability of detailed data and its relevance as a rapidly aging society, but also because it illustrates issues common to many PAYG systems. By integrating regional mortality projections with macroeconomic assumptions, we can capture multiple layers of inequality within a unified framework. The added value lies in the methodology's ability to be transferred to other national contexts, providing a tool for comparative research and policy evaluation.

Methodologically, the paper employs a cash-flow model incorporating regional mortality forecasts and macroeconomic scenarios. Redistribution is quantified by comparing real IRRs across groups, enabling the systematic evaluation of gender, regional, and generational differences. While the empirical results provide specific insights into Hungary, the approach is designed to be broadly applicable for pension policy design in aging societies worldwide.

Literature review

Pension systems are an integral part of national social welfare systems. They serve as mechanisms for intertemporal income smoothing and play a vital redistributive function, aiming to provide financial security in old age while addressing inequalities in income distribution, ensuring that vulnerable groups are supported (Been *et al.*, 2017; Choné & Laroque, 2018; Barr, 2020; Jacques *et al.*, 2021). The effectiveness of achieving pension scheme objectives depends on its institutional design (Jang, 2019; Le Garrec, 2012; Li *et al.*, 2020; Ebbinghaus, 2021).

The redistributive function of pension systems operates through various mechanisms, including intragenerational (within the same generation), intergenerational (between different generations, creating an economic and social link between successive cohorts), vertical (from high-income to low-income individuals) and horizontal (between different socioeconomic groups, supporting specific groups such as women, disabled individuals, or those with interrupted careers) redistribution (Grünewald, 2021).

Pension systems can have three broad types of effects on income distribution, differing in the strength of the relationship between pre- and post-retirement income. First, *status leveling* reduces income disparities arising from differences in earnings, employment stability, or career interruptions, through mechanisms such as minimum guarantees, progressive benefits, and targeted redistribution (Pampel & Hardy, 1994; Hardy, 2009; Bravo & Herce, 2022). Second, *status maintenance* preserves pre-retirement income differentials, typically through earnings-related defined benefit or defined contribution schemes linked to prior earnings and contribution histories (Hungerford, 2007; Riekhoff & Järnefelt, 2018). Third, *status divergence* reinforces pre-retirement inequalities, increasing between-group disparities, for instance, through private pension schemes or differences in human capital and life expectancy, which affect both intragenerational and intergenerational fairness (DiPrete & Eirich, 2006; Chetty *et al.*, 2016; Sánchez-Romero *et al.*, 2020; Holzmann *et al.*, 2020; Bravo *et al.*, 2021, 2023; Culotta *et al.*, 2021).

Better life circumstances resulting from higher incomes—which in turn correlate positively with educational achievements—tend to generate higher longevity prospects, but also longer pension payment periods, implying decreased progressivity of redistributive pension schemes and regressivity in DC systems (Brown *et al.*, 2006; Coronado *et al.*, 2011; Bravo *et al.*, 2021; Ayuso *et al.*, 2022).

The fact that in recent decades most OECD countries have responded to continuous longevity improvements and population aging with systemic or parametric pension reforms automatically linking pensions to population unisex life expectancy developments (Ayuso *et al.*, 2021), e.g., through sustainability factors (e.g., Finland, Portugal), statutory (early and normal) retirement ages (e.g., Denmark, the Netherlands), qualifying conditions (e.g., France), annuity factors in Nonfinancial (Notional) Defined Contribution (NDC) schemes (e.g., Sweden, Italy, Poland) or conditional benefit indexation (e.g., the Netherlands) does not necessarily lessen the status divergence implications of unequal lifespans (Álvarez *et al.*, 2021). The redistributive effects of pension schemes depend on individual behavioral responses to institutional design and incentives.

Bravo *et al.* (2023) examine how automatic indexation of the retirement age to changes in life expectancy can be implemented while respecting the principles of intergenerational actuarial fairness and neutrality, considering two approaches and comparing their projections with the age increase strategies currently being planned by countries. They propose setting a constant number of expected years in retirement (CAR) or maintaining a constant ratio of active to retired years over time (CRR) – assuming a fixed entry age into the labor market. In fewer than half of the 23 countries studied, the projected increase in the age limit will reach or exceed the CRR age limit at least once in the next 25 years. Only four countries (Belgium, the Netherlands, Germany, and Slovakia) apply the CAR approach, which requires a higher age limit. Accordingly, both the expected duration of pension payments and the ratio to the active period would increase dynamically, potentially jeopardizing the sustainability of PAYG schemes.

Recent evidence shows that redistribution in old age depends not only on benefit formulas but also on labor-market trajectories and pension design (Doctrinal, 2024; Herrerías & Zamarripa, 2024; Cahill et al., 2024; Polvinen et al., 2025).

Several methods can be used to assess the degree to which pension schemes redistribute between groups and/or cohorts, each with its own advantages and limitations (for a detailed discussion, see, e.g., Börsch-Supan & Reil-Held, 2001; Lefèbvre & Pestieau, 2006; Klos *et al.*, 2022). They include the ratio between the present value of lifetime benefits and the accumulation at retirement, the scheme's internal rate of return, money's-worth measures, the benefit/tax ratio, the affordability and stability of the social contribution rate across generations, the benefit adequacy, progressivity indices, the index of non-contributiveness, or the share of non-earnings-related benefits in total benefits.

Besides the impact of gender and birth cohort, the redistributive function of pension schemes can also be analyzed from a territorial perspective. Regional pension income disparities can arise due to an asymmetric distribution of economic (e.g., growth, labor market, industry composition, cost-of-living), demographic (e.g., aging, longevity, migration), institutional (pension system design, contribution-based vs. universal schemes, public vs. occupational/private pension coverage), and policy-related (e.g., unionization and collective bargaining, political preferences and policies) or social (gender gap, family structures) factors. For example, in earnings-related pension schemes, wage differentials between regions result in higher pensions in regions with higher incomes (Altamirano *et al.*, 2025). Regions with prevalent full-time, formal employment with pension contributions tend to generate higher pensions, whereas an abundance of informal or precarious jobs in a region often results in lower pension benefits. Regions dominated by high-wage industries (e.g., finance, technology) generally provide better pensions compared to regions reliant on low-wage sectors (e.g., agriculture). Government investment in social programs and pension top-ups can mitigate disparities in lower-income regions. Even if pension income is higher in some regions, regional price disparities can impact retirees' real purchasing power.

Regions with older populations that depend on minimum pensions rather than contribution-based benefits may see lower pension incomes. The heterogeneity between regions modifies the redistributive features of pension schemes, as part of the income redistribution may be amplified, neutralized, or even reversed by lifespan differentials, creating a tax/subsidy effect that flows from poorer to wealthier regions, which can impact pension sustainability and benefit distribution (Ayuso *et al.*, 2022). Regions experiencing out-migration of younger, skilled workers may strain their pension systems, leading to reduced benefits for retirees.

Despite its importance, empirical research on the regional redistributive implications of pension schemes is limited, focusing largely on the study of externalities produced by institutional design (Bonasia & De Siano, 2016) or by specific policies, such as minimum pensions (Peinado & Serrano, 2024).

The case of Hungary

The Hungarian pension system is based on three main pillars, each with distinct roles and varying levels of importance (Simonovits & Reiff, 2022).

The first pillar is a mandatory, PAYG public pension scheme. It is primarily earnings-related and provides defined benefits. This system is financed through contributions from both employers and employees, supplemented by general taxation revenue. Eligibility for state pensions is contingent upon meeting a minimum contribution period of 15 years. The state pension comprises various benefits, including old-age pensions, disability pensions, and survivors' pensions. The statutory retirement age is 65 years, but women may retire after 40 years of eligible service time ("Women-40" rule). Means-tested minimum benefits and other targeted support schemes complement the main state pension to assist those with inadequate contribution records, yet these are insignificant.

The second pillar was effectively dismantled in 2010–2011and is no longer operational in practice. The third pillar consists of voluntary individual savings instruments, including private pension funds, life insurance products with pension savings components, and retirement savings accounts.

Entry pensions in the first pillar are determined individually for each person based on their full career average net earnings and the accrual rates applied since 1988. The average income on which the old-age pension is based is computed as

$$\overline{w} = \frac{\sum_{i=1988}^{t_n} w_i v_i}{\sum_{i=1988}^{t_n} d_i} \frac{365}{12}, \tag{1}$$

where $\overline{w}$ is the average net earnings on which the pension is based, w_i is the net income, v_i is the valorisation multiplier, d_i is the number of working days in year i, and t_n denotes the year of retirement. The service time is determined using the following formula:

$$y = \sum_{i=t_1}^{t_n} \frac{s_i}{365}, \tag{2}$$

where y is the number of service years, t_1 is the first year with positive income, and s_i is the number of service days in year i. For each year of service, there is a determined accrual rate c_y, thus the first old-age pension amount is: $Pen_0 = c_y \overline{w},$ where the development of c_y is shown in Table 1. To be eligible for an old-age pension, one must have worked for at least 15 years, and the accrual rate reaches 100% after 50 years of service.

According to the Hungarian Central Statistical Office (HCSO), life expectancy at birth in 2022 in Hungary was 6.5 years higher for women than for men (women: 79.05 years, men: 72.55 years), and there was a difference of approximately 4 years in life expectancies at age 65 in favor of women. While this results in longer periods of pension receipt for women, their average benefit amounts tend to be lower than those of men, primarily due to the persistent gender pay gap in Hungary, which stood at 17.8% in 2023.

Pensions in payment are indexed annually to projected inflation, with an ex post correction if actual inflation exceeds the increase projected in January.

Figure 1 illustrates the territorial diversity of Hungarian pensions, showing the average monthly old-age pension benefit by region in January 2024. On average, the highest pensions are received in Central Hungary, where the capital, Budapest, is located, while the lowest amounts are found in the Southern Great Plain and similarly underdeveloped regions such as the Northern Great Plain and Southern Transdanubia.

In general, the current pension system is unlikely to be sustainable in the long run, given the ongoing aging trend, unless substantial reforms are implemented (Németh *et al.*, 2020; OECD, 2024). Even generous family subsidies are unlikely on their own to significantly boost fertility rates and thereby ensure the long-term sustainability of the pension system (Németh *et al.*, 2025). Possible reforms include a phased increase or automatic indexation of the retirement age, and disallowing or penalizing early retirement.

The inadequacy of long-term savings (Gál & Törzsök, 2020) and negative demographic prospects contribute to overly pessimistic pension expectations (Vaskövi, 2024), compounding concerns over the future financial well-being of retirees.

Research methods

PAYG systems are prone to redistribution across sexes, regions, and cohorts. To assess this phenomenon, we follow Freiden *et al.* (1976) and Schön (2023) in estimating the pension system's internal rates of return. We propose extrapolating mortality, employment, and pension coverage rates, average incomes, and average pensions to compute series of expected contributions and pension benefits of representative individuals by regions, genders, and birth cohorts, with the ultimate aim of calculating IRRs and examining pension inequalities in a descriptive fashion and by means of a linear regression model that allows for rigorous hypothesis testing.

While this methodology is generally applicable to any pay-as-you-go scheme, we have illustrated it with Hungary. We computed expected contributions and pension benefits for representative males and females born between 1970 and 1985 across Hungary's regions, using the regionally disaggregated population projection of the Hungarian Demographic Research Institute (2021) up to 2050, based on the method developed by Lee & Miller (2001). Our analysis is based solely on old-age pensions. Beyond examining actuarial fairness, our approach can also aid future political and social decision-making, which may directly and indirectly impact the social welfare and the quality of life of older generations.

Cash-flow model

The real value of the expected contributions to the pension system (at 2020 price levels) of the representative persons under study in different calendar years is described by Equation (3):

$$\mathbb{E}\left(C_t^{g,r,b}\right) = \begin{cases} P_t^{g,r,b} E_t^{g,r,b} (C_t^1 + C_t^2) 12 \dfrac{Inc_t^{g,r,b}}{\pi_t^{2020}}, & \text{if } 20 < t - b < 65, \\ 0, & \text{otherwise,} \end{cases} \tag{3}$$

$$\text{where } g \in \{\text{male}, \text{female}\},\ b \in \{1970, 1971 \dots, 1985\},$$
$$t \in \{1990, 1991, \dots, 2085\}, \text{ and}$$
$$r \in \{\text{HU10}, \text{HU21}, \text{HU22}, \text{HU23}, \text{HU31}, \text{HU32}, \text{HU33}\}.$$

Here $C_t^{g,r,b}$ denotes the expected contributions paid in calendar year t by a living individual of gender g born in region with NUTS-2 code r in year b, $P_t^{g,r,b}$ is the conditional probability that the person is alive in year t (i.e., at age $t-b$) given that they were alive at age 20, $E_t^{g,r,b}$ is the corresponding employment rate, C_t^1 and C_t^2 are the employer's and employee's[2] pension contribution rates, $Inc_t^{g,r,b}$ are average gross monthly earnings, and π_t^{2020} is the relative price level compared to 2020 prices.

Expected annual old-age pension benefits are given by Equation (4):

$$\mathbb{E}\left(B_t^{g,r,b}\right) = \begin{cases} P_t^{g,r,b}(12+\chi_t)Pr_t^{g,r,b}\dfrac{Pen_t^{g,r,b}}{\pi_t^{2020}}, & \text{if } t-b \geq 60, \\ 0, & \text{otherwise.} \end{cases} \tag{4}$$

where $Pr_t^{g,r,b}$ is the proportion of pensioners within the given subpopulation, assumed to be 1 if $t-b \geq 65$, and 0 for men with $60 \leq t-b < 65$, χ_t is the indicator variable for 13th-month pensions, and $Pen_{r,b,t}^G$ denotes the average monthly old-age pension benefit.

Expected net cash flows are the differences between expected benefits and contributions:

$$\mathbb{E}\left(CF_t^{g,r,b}\right) = \mathbb{E}\left(B_t^{g,r,b}\right) - \mathbb{E}\left(C_t^{g,r,b}\right). \tag{5}$$

Real IRRs are obtained by solving Equation (6) numerically:

$$0 = NPV^{g,r,b} = \sum_{t=b+20}^{b+100} \frac{\mathbb{E}\left(CF_t^{g,r,b}\right)}{(1+IRR^{g,r,b})^{t-b}}. \tag{6}$$

Since each series of expected cash flows changes signs exactly once, the IRR is always unique.

Data and assumptions

We constructed our models using tabular datasets compiled by the HCSO on our request and Eurostat (2024) data. We applied the contribution rates

[2]Starting from 2012, $C_t^1 = SCR_t PFR_t$, where the term on the right-hand side represents the portion of the social contribution tax allocated to the pension insurance fund. The remaining share is directed to the public health insurance fund.

C_t^1 and C_t^2 in force over the years, using time-weighted averages when rates changed within a year. Since average gross earnings did not exceed the upper limits, it was not necessary to consider the cap on contributions that was in force before it was abolished in 2013. We assumed no future changes in contribution rates after 2024.

The data were typically available for the period 1999–2023, with the most detailed breakdowns provided by the 2001, 2011, and 2022 censuses, as well as the 2016 microcensus. Since early income and employment data for individuals born between 1970 and 1979 were unavailable, it was necessary to extrapolate some series backward to the period 1990–1998. This was done in addition to interpolating missing data and extrapolating into the future.

We assumed labor market participation to be confined to ages 20 to 100, as the 2021 Ageing Report (European Commission, 2021) uses 20 years as the lower limit for typical entry into the workforce, survival beyond age 100 is rare, and several life tables also adopt this upper limit.

We treated "region" as a summary of correlated socioeconomic conditions (earnings, employment, and mortality) observed for residents of a given NUTS-2 region. The model therefore describes expected contribution and benefit streams for a representative individual who resides and retires in the same region. We do not interpret regional differences as causal effects of geography per se; rather, they reflect compositional differences across regions in labor-market trajectories and longevity. We do not explicitly model internal migration. Individuals who migrate may therefore experience expected returns that reflect a combination of the socioeconomic profiles of their regions of work and residence, potentially yielding values between the representative-region estimates reported here.

The statutory retirement age in Hungary has been 65 for both men and women since 2022. From this age onward, we assume individuals to have no earned income and to begin receiving pension benefits. We determined the probability of retirement under the "Women-40" scheme for women aged 60–64, who were assigned both a probability of receiving pension benefits and a probability of contributing to the system, based on the employment rate for their region, cohort, and calendar year.

We did not account for various tax benefits; therefore, we modeled representative individuals who are not eligible for these.

Employment rates

Regional employment rates by age were available only for the census years;[3]

[3] These statistics include the self-employed, who occupy a distinct and less well-protected position in social security systems (Aceto and Aranguiz, 2026).

therefore, the missing data for 1990-2022 were predicted using a multivariate regression model as a function of calendar year, region, sex, and birth cohort, along with their interactions.

Employment rates vary considerably by gender, region, age, and calendar year, and tend to be higher in more economically developed regions (Western Transdanubia, Central Hungary), especially for middle-aged men (30-45 years). As the retirement age approaches, employment declines in all regions, especially for women.

Future employment rates are defined in two parts. In 2023, the representative individuals with the earliest year of birth are aged 53; therefore, employment rates for the 54–64 age group—who first enter the model after 2023—are projected based on the 2022 census data and the average annual change in region-, gender-, and age-specific employment rates between 2016 and 2022. This projection is subject to a cap of 90%, given that the highest observed rate for this age group since 2016 was 87%. The upward adjustment beyond the historical maximum is justified by the increasing employment rate projected for Hungary by the 2021 Ageing Report (European Commission, 2021).

For all other age groups, we applied the historical trends in employment rates up to 2029, excluding any regional, gender- or age-specific declines. From 2030 onward, employment rates are assumed to remain constant across all regions, sexes, and age groups.

Income data

Regional average earnings by age and gender were sourced from the HCSO database. Besides economic factors, regional differences in income reflect differences in age composition, as individual income is strongly influenced by work experience, which in turn correlates with age (Dustmann & Meghir, 2005). The highest average incomes for 2023 are recorded in Central Hungary (including Budapest), followed by Western and Central Transdanubia, where earnings are typically 15–16% lower. The region with the lowest average income was the Northern Great Plain, at 35% below Central Hungary.

For the period 2019–2023, earnings were available in 5-year age group breakdowns. For 2003–2018, data were available at the national level by gender and 10-year age groups, and regionally by gender but without age breakdown. We used linear interpolation across ages to estimate average wages for each year and then applied region- and gender-specific multipliers by calendar year to differentiate earnings across territorial units.

Estimates of early-career income for 1990-2002 were derived without regional variation, using 2003 data by region, gender, and age, and adjusted backward using the national wage index. Future wages of representative individuals were projected based on historical real wage growth, adjusted by region-specific patterns.

The forecast is based on the median value of the consumer price index (CPI) tolerance band from the 2024 Inflation Report of the Hungarian National Bank, as well as the 3% long-term inflation target. Wages outside 2003–2023 were estimated using Equation (7):

$$\widehat{Inc}_t^{g,r,b} = \begin{cases} Inc_{2003}^{g,r,b} \dfrac{1}{\prod_{i=t}^{2003} w_i}, & \text{if } 1990 \leq t < 2003, \\ Inc_{2003}^{g,r,b} \prod_{i=2024}^{t} \widehat{w}_{r,i}\,, & \text{if } 2024 \leq t < 2050. \end{cases} \tag{7}$$

Here w_i denotes the wage index in year i and $\widehat{w}_{r,i}$ is the regional wage index as follows:

$$\widehat{w}_{r,i} = \begin{cases} (1 + \widehat{w}_i)\overline{rw}_r^{diff}, & \text{if } 2024 \leq t < 2030, \\ 1 + \widehat{w}_i, & \text{if } 2030 \leq t < 2050, \end{cases} \tag{8}$$

where $\widehat{w}_i = CPI_i + 3\%$. The theoretical basis for the 3% increase in real wages is the average annual real wage increase in Hungary since the country joined the European Union in 2004, and $\overline{rw}_r^{diff}$ is the time series average of the yearly regional relative deviations from the national real wage increase calculated from 2016–2023 data.

Pension data

Regarding pension data, we considered two factors in the cash-flow model: the proportion of pensioners and the amount of pension paid. For the latter, it is sufficient to determine the initial (entry) pension amount. In subsequent years, to preserve the real value of pensions, the previous year's amount is indexed annually using the (expected) CPI of the current year. Toward the end of the year, this is retroactively adjusted if actual inflation exceeds the earlier expectation.

We assume that men retire deterministically at the statutory pensionable age, while women may retire between ages 60 and 64 under the "Women-40" scheme. The proportions of female early retirees were based on the 2023 ratios and applied to subsequent calendar years, without incorporating spatial variation, but with constraints that ensure the sums of retirement probabilities and corresponding employment rates do not exceed 100%.

The projection of initial pension benefits for representative individuals was based on HCSO data that provided average old-age pension benefits by region, gender, and 5-year birth cohort. The age-disaggregated data were produced by linear interpolation.

By subtracting the respective year's inflation rate from the changes in age-, region- and gender-specific pensions for the period 2012–2023, we obtained annual real rates of increase. The averages of these across the three variables were used to determine the initial benefits for the representative individuals between 2024 and 2030. The lowest real increase was observed among females aged 60 living in Central Hungary (2.47%), and the highest was observed among men aged 65 from Central Transdanubia (3.71%).

Initial benefits in the future are determined by Equation (9):

$$\widehat{Pen}_t^{g,r,b} = \begin{cases} Pen_{2023}^{g,r,b} \prod_{i=2024}^{t} \left(1 + CPI_t\right)\left(1 + \overline{rpi}_i^{g,r,b}\right), & \text{if } 2024 \leq t \leq 2030 \\ \widehat{Pen}_{2030}^{g,r,b} \prod_{i=2031}^{t} \left(1 + CPI_t\right)\left(1 + \overline{rpi}^{g}\right), & \text{if } t > 2030 \end{cases} \quad (9)$$

for $g =$ male and $t - b = 65$, as well as for $g =$ female and $60 \leq t - b \leq 65$. Here $\overline{rpi}_i^{g,r,b}$ denotes the average real mean pension increase at age $i - b$ from 2012 to 2023, and $\overline{rpi}^{g}$ denotes the averages by gender. Initial pensions are subsequently indexed to the CPI.

As our data show, younger cohorts can expect higher pensions than older cohorts who have already retired. Regional and gender differences are also significant.

Survival probabilities

In our cash-flow model, both contributions and benefits are proportional to the survival probabilities $P_t^{g,r,b}$. For the period 1990–2019, we used observed data from the HCSO database. For the years 2020–2022, we utilized population statistics from the HCSO and mortality data from Eurostat. Future values were obtained from regional cohort-based mortality projections by gender, as provided by the Hungarian Demographic Research Institute (2021). We derived survival rates from the mortality rates starting in 1990.

Regional data and projections were only available up to age 90, beyond which we derived survival probabilities up to age 100 from cohort, sex, and region-specific data according to the pattern of the latest 2020 national male and female period mortality tables available for Hungary from the Human Mortality Database (HMD, www.mortality.org), according to Equation (10):

$$P_{r,b,t}^{G} = \begin{cases} \dfrac{l_t^{g,r,b}}{l_{b+20}^{g,r,b}}, & \text{if } 20 \le t-b \le 90, \\ \dfrac{l_{90}^{g,r,b}}{l_{b+20}^{g,r,b}} \dfrac{l_{t-b}^{g}}{l_{90}^{g}}, & \text{if } 91 \le t-b \le 100, \end{cases} \tag{10}$$

where $l_t^{g,r,b}$ indicates the number of persons born in year b and alive in the middle of calendar year t by gender and region, and l_{t-b}^{g} is the value for age $t-b$ in column l_x of the national period mortality table for 2020 for men and women separately.

We observed significant differences in survival probabilities to age 65 across regions. Additionally, gender differences in favor of women tend to decrease over time and exhibit regional variation; for example, they are smaller in Central Hungary than in other regions.

Strengths and weaknesses

Our methodological framework combines demographic, economic, and actuarial components in a coherent structure. We developed a cash-flow model that reflects contributions and benefits by gender, cohort, and region, using a finer level of data granularity than typically found in national redistribution analyses. Regional mortality projections were linked with wage and employment assumptions to establish a demographic–economic connection. Using real IRRs as a summary indicator allows a clear, consistent, and interpretable assessment of actuarial fairness. The analysis covers 224 representative individuals across seven regions, sixteen birth cohorts, and both genders, ensuring broad policy relevance. The methodology is adaptable to PAYG systems of other countries.

At the same time, our approach relies on several simplifying assumptions. The use of representative individuals abstracts from intra-regional heterogeneity, overlooking differences in education, occupation, migration, and health that can materially affect lifetime outcomes. This constraint is necessary due to data limitations and can be relaxed with sufficient data. We do not model migration or career mobility; however, our results are valid for representative individuals and can be approximated for others through interpolation. Our framework is deterministic, projecting demographic and macroeconomic variables without stochastic treatment, as uncertainty cannot be cleanly expressed for imputed, interpolated, extrapolated, or highly correlated data series. However, trends and policy conclusions can still be discerned from point estimates. Moreover, we focus only on old-age pensions, omitting disability and survivors' benefits that could influence redistribution patterns, particularly across genders. The analysis of these significantly smaller, complementary subsystems is outside the scope of our analysis. Finally, we assume fixed contribution rates and macroeconomic processes over long horizons, thereby applying the ceteris paribus condition, which is a necessity in standard economic analyses.

Hypotheses

As prior hypotheses, we expect:

H1: No significant differences in returns by gender, ceteris paribus, as men's higher earnings offset their lower life expectancies.

H2: Higher returns in the most developed region of Central Hungary than elsewhere, ceteris paribus, due to higher incomes and longer life expectancies.

H3: Higher returns for those born later, ceteris paribus, reflecting the substantial real wage growth of the past decade.

Results

The computed real IRRs for the 1970, 1975, 1980, and 1985 cohorts are shown in Figure 2, illustrating differences across regions, genders, and cohorts. Women are more likely than men to benefit from the system, regardless of year of birth or region. For individuals born in 1970, IRRs for women can be more than twice those of men in some regions (e.g., Central Hungary, HU10). This is due to women's longer life expectancy and the "Women-40" allowance, despite their lower average incomes. Although gender differences decrease over time, they do not disappear within the time horizon studied.

Among all regions, representative residents from Central Hungary (including Budapest) have the lowest IRRs for both sexes and across all birth years. In high-wage regions, contributions rise more strongly with earnings than expected benefits do under degressive benefit rules, and the longevity advantage may not fully offset this, resulting in lower expected IRRs.

Later birth cohorts tend to exhibit higher expected returns. This pattern is driven mainly by rapid real wage growth in recent decades and rising life expectancy, which together increase projected pension streams and their expected duration.

For men, except in Central Hungary, yields are spread within a relatively narrow range in all cohorts. IRRs increase most dynamically in Central Hungary, thus reducing its gap relative to other regions. The maximum IRR for men is 2.37% (for Southern Transdanubia and the 1985 cohort). For women, yields are higher and range more widely. The highest values are found in Northern Hungary, the Northern Great Plain, and Southern Transdanubia, with rates above 3% for cohorts born in the 1970s, reaching 3.5% for the 1985 cohort. The maximum IRR for women is 3.46% (for Northern Hungary and the 1985 cohort). Even the highest male IRR is lower than the lowest female value.

Additionally, we have examined the impact of abolishing the “Women-40” allowance and found that it would decrease women’s IRRs by 0.5 percentage points in almost all regions, except for Central Hungary, where the effect would be approximately 0.3 percentage points smaller.[4] Additionally, the abolition of the 13th-month pension would impact real returns but would not significantly alter the relative differences between them.

On average, the Hungarian pension system can achieve a real return of 2.4% with a standard deviation of 0.67 percentage points across groups. If a cohort is one year younger, their IRR is typically 0.03 to 0.04 percentage points higher. Gender and regional variation tend to decrease slightly over time. A summary of the results is shown in Table 2.

To identify the partial effects of year of birth, region, and gender on real returns, we constructed a linear regression model that included these variables, along with the interaction term between year of birth and gender, given the varying dynamics of yields over time. We subtracted 1970 from the year of birth so that the constant term was the estimated real return of a representative woman born in 1970 in the reference region (Central Hungary). The results are presented in Table 3.

For women, a one-year increase in year of birth is associated with a 0.02 percentage-point higher average real IRR, holding all other factors constant. By contrast, the effect of year of birth on IRR is, on average, twice this large for men. Compared to Central Hungary, the model estimates higher IRRs across all other regions, with Southern Transdanubia predicted to have the highest rates, assuming all other factors remain equal.

Discussion

Based on the results, we conclude that the Hungarian pension system tends to redistribute resources—at least in relative terms—from men, older individuals, and those in higher-income regions to women, younger

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[4] Simonovits (2019) shows that, under rapid real wage growth, immediate retirement under Women-40 may reduce lifetime pension benefits relative to delaying retirement.

individuals, and those in lower-income regions, not accounting for additional sources of heterogeneity (e.g., education or health status).

Empirical evidence on IRRs in pay-as-you-go pension systems reveals substantial variation across countries, cohorts, and income groups. For the United States, Freiden *et al.* (1976) estimated that real IRRs for beneficiaries retiring between 1967 and 1970 averaged approximately 12 percent for males and 18 percent for females, reflecting generous early returns during the baby boom and the strong redistributive character of the Social Security program. Schön (2023) reported moderate returns of 0-1.4% in the German system, with the IRRs of successive cohorts approaching zero over time. In the United States, Sánchez-Romero *et al.* (2020) reported that simulated IRRs by income quintile range from roughly –0.4 to 2.7 percent under alternative pension designs, while fully mortality-adjusted notional defined-contribution systems yield returns of about 2 percent. Altamirano *et al.* (2025) report an average IRR of 4.07% for private pensions in Latin America and the Caribbean, and although it primarily assesses implicit subsidies rather than explicit IRRs, it cites U.S. Social Security returns of roughly 2.3 to 4.3 percent as comparative benchmarks.

These figures, however, are not directly comparable to our results for Hungary, given the vastly different institutional, demographic, and labor market contexts. Moreover, no similarly comprehensive, data-driven analysis of IRRs has yet been conducted for the Hungarian pension system.

In a mature PAYG pension system under steady-state assumptions, the sustainable real IRR equals the growth rate of the contribution base, i.e., approximately the sum of labor-force growth and productivity/real wage growth (Settergren & Mikula, 2005). Thus for Hungary, over a long-run horizon (e.g., 2025–2050), the sustainable real IRR can be approximated by combining projected negative contributor growth of about −0.5% to −1.0% per year with a real wage growth of about 1.5% to 2.0%, yielding a central estimate close to 1% (European Commission, 2021). As the computed average real IRR of 2.4% substantially exceeds this benchmark, it suggests that, without offsetting adjustments, the current parameterization of the system is not financially sustainable in the long run, in line with existing projections (Németh et al., 2020; OECD, 2024).

Conclusions

Using tabular datasets on labor market, demographic, and old-age pension data from the HCSO and Eurostat, this paper examines gender-, region-, and cohort-based inequalities in the Hungarian pension system for individuals born between 1970 and 1985. The analysis adopts a different approach from the existing literature by comparing the expected values of monetary flows affecting the pension system, all measured at constant prices. IRRs are calculated for 224 representative individuals, covering 7 regions, both genders, and 16 birth years.

Our results suggest that all region-cohort-gender combinations are expected to achieve positive IRRs, assuming no parametric or paradigmatic changes to the system in the future.

Table 2 shows that all computed female IRRs exceed all computed male IRRs, and pairwise comparisons reveal differences of up to threefold between genders in some cells. The marginal effect of being male on the expected real IRR is given by the linear combination β_{male} + (YOB – 1970) $\beta_{\text{interaction}}$, which varies with year of birth (YOB). Evaluating this combination over the relevant range (1970–1985) using the values shown in Table 3 yields consistently negative effects, and formal Wald tests of the corresponding linear restrictions confirm that the combined coefficient is statistically significant at the 5% level for all birth cohorts considered. Accordingly, the results provide robust evidence that, ceteris paribus, male IRRs are lower than female IRRs throughout this period, which refutes hypothesis H1. Thus the higher pension benefits received by men are more than offset by the combined impact of women's longer life expectancy and the "Women-40" provision. Furthermore, since married women tend to live longer and are typically younger than their spouses, they are even more likely to benefit from the system through survivors' pensions. These differences may be interpreted as implicit compensation for the unpaid household work that women predominantly perform throughout their lifetimes.

We hypothesized in H2 that Central Hungary would exhibit higher pension returns than other regions, ceteris paribus, given the positive association between income and life expectancy. However, our results have revealed the opposite (t-test: $p < 0.05$, and $\beta_{\text{region}} > 0$ for all regions, with Central Hungary being the reference). For both genders, Central Hungary consistently exhibits the lowest IRRs across all birth cohorts, despite having the highest earnings. Western and Central Transdanubia—also higher-income regions—tend to have high returns for men but relatively low yields for women. This may reflect the fact that higher earnings lead to greater contributions and benefits, while only modest gains in life expectancy limit the advantages of larger pension payments in terms of IRRs.

Finally, our results have confirmed hypothesis H3, which stated that younger cohorts achieve higher IRRs, ceteris paribus (t-test: $p = 0.0000 < 0.05$ and $\beta_{\text{birth year}} > 0$). This trend is observable across all regions and both genders. IRRs for males also rise more dynamically over time than those for females.

While we find no evidence of perverse redistribution by region or gender, such effects may occur at the individual level—for instance, by education. The 13th-month pension has only a marginal effect on regional or gender-based inequalities, whereas the "Women-40" rule significantly tilts the balance in favor of women.

Overall, real expected returns range from 1.1% to 3.5%, with notable differences across regions, genders, and birth cohorts. These returns compare favorably to the real yields of Hungarian inflation-linked government bonds, which offer a premium of 0.5–1.5%. Compared to riskier investments, the IRRs of younger cohorts exceed the 1.59% average real return of the BUX index (2013–2023), although they remain well below the 6.37% historical return of the S&P 500 index. Thus, for representative individuals with average labor market characteristics, participation in the pension system may offer competitive returns relative to domestic investment alternatives.

Policy implications

If policymakers aim to enhance the fairness and equity of the pension system by reducing inequalities across regions, genders, or birth cohorts, they may introduce interventions either during the accumulation phase or at the retirement stage. Addressing such disparities often involves trade-offs—most notably, balancing fairness across demographic groups with the administrative complexity and potential costs of implementing differentiated policies.[5] Rather than advocating for or against specific reforms, our objective is to provide a descriptive overview of possible approaches.

Intervention at the accumulation stage

To reduce inequalities during the accumulation stage, policymakers could adopt a two-tier contribution scheme, as proposed by Ayuso *et al.* (2017) for DC systems. This approach consists of two parts: a fixed contribution amount and an income-proportional component.

Another simple strategy is to reintroduce the previously abolished cap on contributions, which would mitigate unwanted redistribution.

A further potential measure is to introduce regionally differentiated contribution rates, provided there are no constitutional barriers. The justification for this lies in regional disparities in longevity.

[5] We remark that while our model could be used to determine the specific parameters required to equalize IRRs across regions, genders, and cohorts, such an analysis falls outside the scope of this paper.

Beyond reforms to the pension system itself, governments can promote fairness by addressing the underlying structural inequalities that contribute to differences in IRRs—such as disparities in longevity, earnings, and employment—through targeted job creation and healthcare improvements for specific groups.

Intervention at the retirement stage

To address gender inequality in retirement, Hungarian policymakers might consider abolishing the "Women-40" allowance. On the one hand, this reform could mitigate perceived gender-based discrimination within the system and reduce the current advantage women hold in IRRs. On the other hand, this measure might be viewed as unjust, given women's greater share of unpaid work in childrearing[6], homemaking, and caregiving for the elderly. An alternative approach could involve introducing gender-differentiated accrual rates.

To reduce regional disparities in retirement outcomes, policymakers could consider implementing region-specific retirement ages, assuming there are no constitutional barriers. In the case of inequalities across birth cohorts, adjustments to the wage valorization multipliers in Equation (1) could help equalize IRRs. Alternatively, modifications to the pension indexation rule could be considered to achieve a similar effect.

Limitations

Our results should be interpreted by considering the conditions applied to representative individuals with average labor-market, income, and demographic characteristics for their region and year of birth in each calendar year. A key limitation of the model is the scarcity of sufficiently disaggregated data, which necessitated certain additional assumptions. The model covers a 95-year period, spanning from the entry of the first cohort into the labor market in 1990 to the retirement of the last cohort in 2085. This long horizon required projections of 47 to 62 years, depending on the cohort.

While the absolute level of the estimated IRRs should be interpreted with caution, the use of a consistent methodology provides a realistic picture of inequalities across regions, genders, and cohorts.

It is also important to note that the model excludes disability and survivors' benefits, focusing exclusively on old-age pensions.

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[6] Fathers' leave and fathers' involvement in childcare are closely related (Huerta et al., 2014), yet the uptake of parental leave by fathers remains comparatively low in Hungary.

Additionally, due to data limitations, we could not investigate the impact of the digital labor market and remote work, which may result in cross-border activities, higher income, and ultimately the transfer of pension entitlements. Tandberg (2025) argues that frequent changes in applicable legislation may threaten the legal certainty that is crucial to European social security coordination, posing a challenge for researchers and remote workers alike.

Lastly, our model does not account for regional differences in population composition by educational attainment. Instead, the effects of such differences are indirectly reflected in regional mortality and labor market data. Nonetheless, considerable individual heterogeneity remains (e.g., besides education, also by health status), which could lead to even greater variation than reported in this study. Investigating this using micro-level data is a promising avenue for future research.

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Annex

Table 1: Accrual rates by years of service in the Hungarian pension system

Years of service	*Accrual rate*
< 15	0.0%
15	43.0%
16–25	+2.0% per year
26–36	+1.0% per year
37–40	+1.5% per year
41–50	+2.0% per year

Source: own edition

Table 2: Summary of real IRRs by genders, regions, and birth cohorts (%).

	Mean	*St.dev.*	*Me-dian*	*Min.*	*Max.*
Hungary	2.40	0.67	2.38	1.07	3.46
Male	1.79	0.25	1.80	1.07	2.37
Female	3.01	0.27	2.99	2.39	3.46
Central Hungary	2.05	0.61	2.15	1.07	2.82
Central Transdanubia	2.30	0.55	2.39	1.48	2.96
Western Transdanubia	2.35	0.51	2.43	1.61	2.98
Southern Transdanubia	2.64	0.65	2.73	1.72	3.44
Northern Hungary	2.53	0.78	2.61	1.53	3.46
Northern Great Plain	2.57	0.74	2.65	1.60	3.45
Southern Great Plain	2.38	0.65	2.47	1.47	3.19
1970	2.17	0.74	2.05	1.07	3.16
1971	2.21	0.73	2.10	1.14	3.19
1972	2.25	0.73	2.13	1.20	3.21
1973	2.28	0.72	2.17	1.25	3.24

1974	2.27	0.71	2.17	1.27	3.20
1975	2.31	0.70	2.21	1.33	3.22
1976	2.34	0.69	2.25	1.39	3.24
1977	2.37	0.67	2.28	1.44	3.25
1978	2.40	0.66	2.32	1.50	3.27
1979	2.44	0.65	2.36	1.56	3.30
1980	2.48	0.64	2.41	1.62	3.33
1981	2.51	0.63	2.44	1.67	3.33
1982	2.55	0.62	2.48	1.73	3.38
1983	2.59	0.62	2.53	1.79	3.42
1984	2.63	0.60	2.56	1.85	3.44
1985	2.66	0.59	2.59	1.91	3.46

Source: own calculations

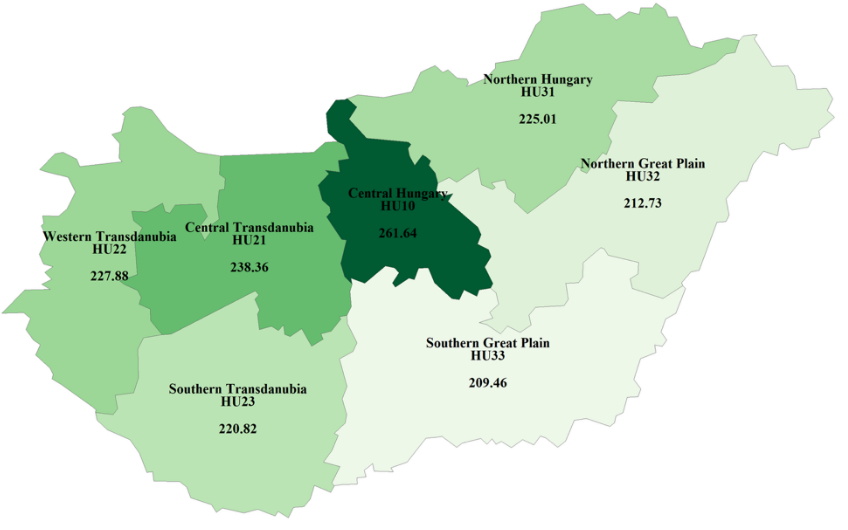
Table 3: Regression results

	Dependent variable
	Real IRR
Constant	0.0249***
(Year of birth – 1970)	0.0002*** (0.0000)
r: Southern Great Plain	0.0034*** (0.0003)
r: Southern Transdanubia	0.0060*** (0.0003)
r: Northern Great Plain	0.0052*** (0.0003)
r: Northern Hungary	0.0048*** (0.0003)
r: Central Transdanubia	0.0025*** (0.0003)
r: Western Transdanubia	0.0030*** (0.0003)
G: Male	-0.0137*** (0.0002)

(Year of birth – 1970) · *G*: Male	0.0002*** (0.0000)
Observations	224
R^2	0.9780
Adj. R^2	0.9771
Note	**p<0.1; **p<0.05; ***p<0.01*

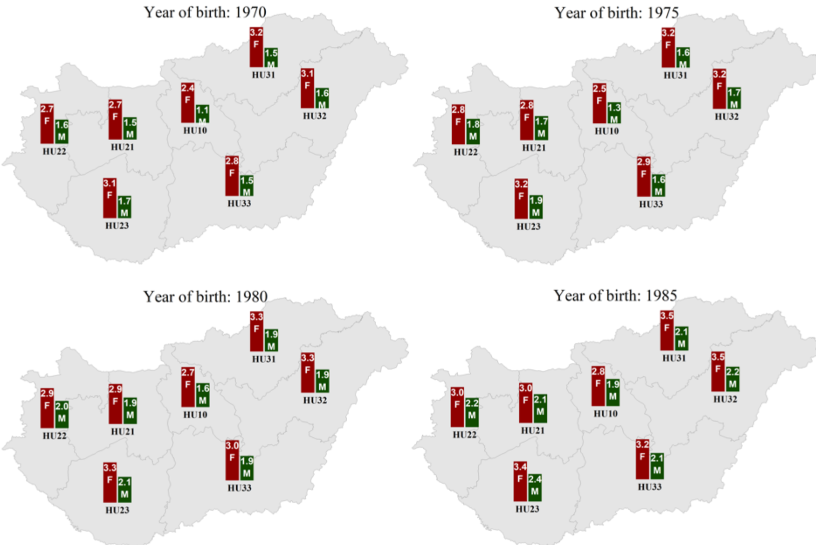
Source: own calculations

Figure 1: Average old-age pension by region in thousand HUF, January 2024.



Source: own edition based on data provided by HCSO on our request

Figure 2: Real IRR by region and gender for cohorts born in 1970, 1975, 1980, and 1985 (%).



Source: own calculations