FUTURE PENSION BALANCES: AGING PATTERNS AND POTENTIAL PENSION REFORMS IN REPUBLIC OF KOREA AND HUNGARY

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KEYWORDS

Population Aging, Pay-as-you-go Pension System, Pension Sustainability, Calibrated General Equilibrium Model, Human Capital.

ABSTRACT

We investigate the sustainability of pension systems in the context of aging societies and significant intergenerational imbalances in the age pyramid. Using concrete examples and a general equilibrium model with infinitely optimizing agents, we simulate that the aging pattern of an economy matters for the pension balance and that the necessary policy responses and incentives depend on this. We consider a country with a very rapid and sustained aging trajectory, Korea, and by contrast, a country with a slow, steady aging trajectory, Hungary as an example. We use the median version of the UN population projection (United Nations, 2024) for the values of future population ratios and model how dynamic changes in population ratios and certain parametric pension reforms affect the sustainability of the country's pension balance to GDP ratio from present till 2080. Our results show that in Korea, a pension reform driven by a gradual increase in the official retirement age combined with an increase in pension contributions is unavoidable, while in Hungary, given the already high tax and contribution rates on labor, it is mainly the increase in the retirement age that could make the biggest contribution to improving the pension balance.

INTRODUCTION

The decline in the birth rate and the parallel increase in life expectancy at birth is causing aging in many countries, one manifestation of which is the rising ratio of older people to the working-age population, and the other one is the unprecedented phenomenon of reversed population pyramids. An essential and much-researched question is how to mitigate the increasing pressures caused by this demographic change on aging-related government spending, namely, on the pension system's sustainability. Since the evolution of the population is slow and predictable, the size of future generations, i.e., the population's age structure, can be well estimated using current demographic trends. Conversely, the resulting complex economic processes that may dampen or even amplify the effects of demographic change are more difficult to quantify.

A number of studies have shown that the upheaval of age structure and the shift towards older age groups have negative economic consequences in the long run (see, for example, Choi and Shin 2015; Jones 2020; Kim et al. 2016; Maestas et al., 2023). In a related study, Kovács and Vaskövi (2019) highlight the disparity between the rise in life expectancy and the stagnation of official retirement ages in many OECD countries, emphasizing the financial burden that aging populations place on pension systems. This phenomenon is similarly observed in countries like Korea and Hungary, where demographic shifts exacerbate the challenges of maintaining pension system sustainability. The problem is particularly acute when the negative demographic trend is coupled with a pay-as-you-go pension system or when the pension system has a pay-as-you-go pillar. Therefore, the appropriate economic policy response may differ from country to country, depending on the level and timing of aging and the parameters of the pension system (e.g. OECD, 2023).

In this paper, we focus on the sustainability of pension systems in the context of aging societies and significant intergenerational imbalances in the age pyramid. Using concrete examples and a general equilibrium model with infinitely optimizing agents, we simulate that the aging pattern of an economy matters for the pension balance and that the necessary policy responses and incentives depend on this.

Our model considers the ratio of the young to the working-age population and the older people to the working-age population as key variables. As an example, we consider a country with a very rapid and sustained aging trajectory, Korea, and by contrast, a country with a slow, steady aging trajectory, Hungary. We use the median version of the UN population projection (United Nations, 2024) for the values of future population ratios and model how dynamic changes in population ratios and certain parametric pension reforms affect the

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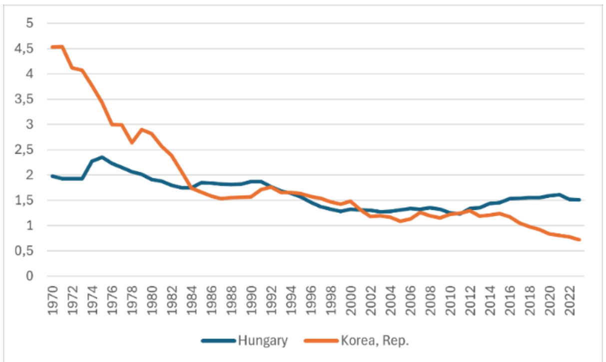
sustainability of the country's pension balance to GDP ratio from the present till 2080.

Our results show that in Korea, a pension reform driven by a gradual increase in the official retirement age combined with an increase in pension contributions is unavoidable, while in Hungary, given the already high tax and contribution rates on labor, it is mainly the increase in the retirement age that could make the biggest contribution to improving the pension balance.

DEMOGRAPHIC CHANGES IN THE REPUBLIC OF KOREA AND HUNGARY

The aging of society can be monitored and measured in both countries, but the underlying demographic dynamics are different. Examining the time period from 1970 to the present, the total fertility rate (TFR) in Hungary has moved within a relatively narrow range in comparison to Korea over the period (see Figure 1), with a maximum of 2.27 in the 1970s and a minimum of 1.23 in 2011. Over the last decade, Hungary has been in the middle of the OECD countries with a TFR of around 1.5 (World Bank, 2025; HCSO, 2025). In contrast, Korea's TFR fell from an initial very high level of 4.5 in the mid-1980s to approximately the same level as Hungary's at that time. Interestingly, the two countries' total fertility rates did not differ significantly until the mid-2010s, i.e. for three decades (see Figure 1). However, in Korea, there is a matter of concern that the slowly deteriorating fertility trend has accelerated over the past decade, falling to a world low of 1 below 0.72 by 2023 (World Bank, 2025; KOSIS, 2025).



Figures 1: Total fertility rate in Hungary and the Republic of Korea, 1970-2023

Source: World Bank (2025), for the year 2023 in Hungary HCSO (2025) and in Republic of Korea KOSIS (2025)

As a consequence, Hungary witnessed a significant and permanent drop in the number of live births between the mid-1970s and the mid-2000s. After this year, it has been on a slow downward trend with minor and temporary fluctuations. By 2023, the number of births has halved since its peak in 1970. In Korea, except for two short periods (1990-94 and 2008-10), the number of live births has followed a strong negative trend from 1970 until the present, with the number of newborns falling by almost a quarter compared to the 1970 level (UN, 2024).

Average life expectancy at birth differs more significantly between the two countries. In Korea, economic development has led to a steady increase in the indicator over the last 55 years, and it has already passed the level of Hungary in 1986. In Hungary, a dynamic improvement can only be observed after the change of regime in 1993. The gap between the two countries has gradually widened over the past decades and then widened even further during the years of the Pandemic. In 2023, the gap between the value of average life expectancy at birth of the two countries was 6.6 years (OECD, 2025).

The phenomenon of relatively low net migration is evident in both countries, with population trends primarily influenced by natural demographic processes (OECD, 2024d). Hungary has experienced a continuous decline in population since 1980, a consequence of the aforementioned demographic processes. Conversely, Korea had witnessed a period of population growth that spanned several decades from 1970, reaching its peak in 2020. It is projected that this year will mark a turning point, with a long-term decline in population for Korea (UN, 2024). It is also common that a reversed or constrictive population pyramid characterizes both economies, indicative of the interpreted demographic changes. The old-age dependency ratio shows a more substantial increase since 2000 in both countries, but Korea is expected to overtake Hungary in 2026 due to a dynamically deteriorating demographic picture. This means that the number of older people per 100 working-age people in the 110 years under study could rise from under 10 to almost 120 in Korea and from 20 to 50 in Hungary (see Figure 2).

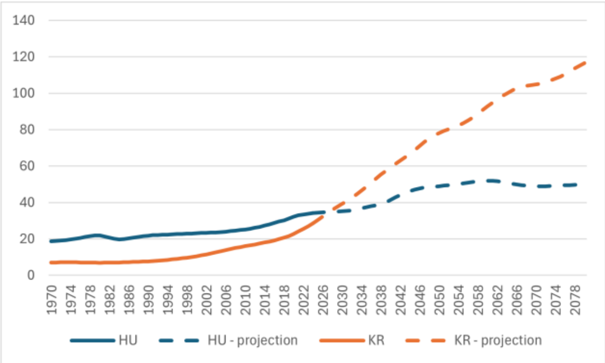


Figure 2: The real (1970-2024) and the future (2025-1980) estimated old-age dependency ratios in Hungary and the Republic of Korea,1970-2080

Source: Own calculations based on UN (2024) data.

Note: The solid lines are the real data, and the dashed lines signify the ratio's projected value from 2025.

PENSION SYSTEM OF KOREA AND HUNGARY

A key requirement for state-run pension systems is that older people receive an adequate income during their retirement years and that the system would be financially sustainable. The state-run pension systems are usually the pay-as-you-go system (PAYG), which is based on a multi-generational partnership: young and middle-aged active generations provide the revenue (pension contributions), and older generations provide the expenditure (pensions) (Lee, 2016). Members of society who have reached retirement age and have completed a certain number of years of service become eligible for a pension, providing them with an income for their retirement.

Because since 2011, Hungary has been operating a pure PAYG defined benefit (DB) pension system in which participation is compulsory for all; due to aging, it is becoming more expensive for the state to maintain the pension system; see Vékás (2021) for more detailed calculation. With the steadily increasing retirement age, Hungary reached 65 years for both women and men by January 2022; this is actually the legal retirement age. Women have the possibility to retire before the age of 65 if they have 40 years of service ("Women 40" scheme) (ONYF, 2017). In the Hungarian pension system, the pension benefit is determined by the amount of previous contributions, which is 10% of the gross wage, i.e. the pension amount depends mainly on the length of service time and the average wage. In Hungary, low-income earners with at least three children can get a pension contribution tax relief (see Varga, 2023), but the extent of this is negligible. Due to aging, it is becoming more expensive for the state to maintain the pension system; see Vékás (2021) for more details. According to OECD (2024c) estimates, public pension expenditure in Hungary is expected to rise from an actual 7.7% to 12% of GDP by 2070, which, without policy changes, would contribute to a significant increase in public debt (OECD, 2024c).

In Korea, the official retirement age will also be gradually raised from 60 to 65 between 2013 and 2034, the 65-year-old age limit will first apply to those born in 1969 (OECD, 2022). Their social security contribution will also include a 4.5% pension contribution for employees, which will be paid into the National Pension Scheme (NPS) fund. The employer will also contribute 4.5%. The NPS covers the majority of Korean workers, as non-contributory pension expenditure is relatively low. This research focuses exclusively on the NPS, which operates as a pay-as-you-go defined benefit (DB) scheme similar to the Hungarian one but with a substantial reserve. This scheme accounts for approximately two-thirds of total pension expenditure and is increasing (Baksa et al., 2024). In Korea, one of the possible pension reform proposals is to increase the combined rate of employer and employee pension contributions, which has remained unchanged for 27 years. The country's pension fund is projected to be depleted by 2056, despite the fact that now it is one of the largest in the world (OECD, 2023). In addition, among OECD countries, Korea has the highest old-age poverty rate, which means that more than 40% of the population older than 64 falls below the poverty line (OECD, 2023).

Table 1 summarizes the main parameters of the pension system used in our model for Hungary and Korea. According to this, the gross pension replacement rates at average gross earnings for 65 years in mandatory schemes was 31.2% for Korea and 52.4% for Hungary in 2023 (OECD, 2023 Table 4.1, 151.p.).

Table 1: The main parameters of the pension system in Republic of Korea and Hungary, 2024

	Korea (KR)	Hungary (HU)
retirement age	63 (2024, 2025, 2026)	65
pension contributions	4,5% - employee	10% - employee
personal income tax for pensioners	Full or partial relief for pension income	Full or partial relief for pension income
elements of the pension system	Basic Pension + National Pension System (DB) + Voluntary Pension Scheme	pure PAYG (DB) pension system
gross pension replacement rates to average earners at retirement age (%), mandatory schemes	31,2%	52,4%

MODEL

There are six main factors that affect the sustainability of the pension system:

- how many pensioners should be paid a pension,
- how long (when is the retirement age and what is the life expectancy),
- how many people pay pension contributions,
- how much pension contributions they pay,
- what is the pension payment rule, and
- the economic environment, i.e. the interest that the pension scheme has to pay on any debt and the total income that active economic agents contribute to financing pensions.

Our aim is to understand how the two investigated countries, which on the surface face the same demographic problem but will have significantly different demographic dynamics expectedly in the future, can most effectively ensure the sustainability of the pension system. To do this, we have developed a general equilibrium model that considers not only demographic differences but also differences in the pension system, the economic environment, investment, and the capacity to renew human resources. Other exogenous variables and parameters are common for both countries. The model is able to focus on the effects of the pension system's parameters:

1. In the model, the current and projected ratio of the number of pensioners to the contributing active population was calculated based on the median version of the UN population forecast (2024), which was included as an exogenous variable in the model. The increase in the retirement age can be simulated by shifting the age limit of this demographic ratio.

2. Pensions appear in the model as an exogenous variable - a lump-sum transfer. This enables us to examine the impact of premium adjustments on the sustainability of the pension system while also separating pensions from the income of active economic participants. This expands the policy action toolkit for pension system sustainability by introducing an additional element: promoting economic growth. Given specific demographic ratios, a higher GDP creates a larger contribution base, allowing policymakers to finance the same pension payments from a larger economic output.

3. Pension contributions are also treated as an exogenous variable. Moreover, to focus as much as possible on the role of the six key factors affecting pension system sustainability, pension contributions are the only exogenous variable in the model that directly distorts labor market behavior.

4. Since output is modified by capital factors and the level of human resources, in addition to the active population as determined by demographic variables, in our model, the representative active economic agent spends not only on capital accumulation but also on developing the skills and abilities of future generations.

In the model, the economy is driven by the decisions of a representative agent optimizing over an infinite horizon and the environment shaped by demographic changes. The representative agent decides on its own consumption and that of its dependent children, on the expansion and replacement of physical capital stock through its savings, on the development of the human capital of its dependent children, on its own labor supply, and on the financing of consumption by older agents under conditions set by the economic policy maker. The agent's decisions are driven by the following utility function:

$$U = \sum_{t=1}^{\infty} \beta^{t-1} \left(\frac{c_t^{1-\sigma}}{1-\sigma} + \Psi \frac{(1 - l_t - lch_t)^{1-\eta}}{1-\eta} + \right.$$

$$\left. +\Phi \frac{\left(\frac{CH_t}{N_t} h_t\right)^{1-\nu}}{1-\nu} \right), \tag{1}$$

where c_t, l_t and lch_t denote consumption, labor supply, and time spent with the children, respectively, CH_t is the number of individuals in the child cohort, and N_t represents the number of agents in the active adult population and h_t is the skills of these children ($\frac{CH_t}{N_t} = ch_t$). While searching for the optimal path of the variables, the agent must consider the time series of the following budget constraints (Eq. (2)):

$$(1 - \tau_t) w_t ha_t l_t + (1 + r_t) s_t + inh_t =$$
$$= (1 + ch_t x) c_t + e_t + s_{t+1}. \tag{2}$$

This indicates that the agent earns income from work $w_t ha_t l_t$ and from accumulating financial assets $(1 + r_t) s_t$, which he/she uses to finance his own consumption (c_t) and that of his children (for simplicity, we assume that the child's consumption is x fraction of the agent's consumption), to finance the community services necessary for the upbringing of his children (e_t) and to accumulate new assets (s_{t+1}). In addition to these activities, he contributes τ_t ratio of his labor income to the pension fund.

As the number of active agents changes over time, the number of agents involved in the accumulation of assets does not match the number of users of the returns from assets, so the returns that become "unmanageable" due to demographic changes are distributed as inheritance among active agents like this: $inh_t = \frac{N_{t-1} - N_t}{N_t} (1 + r_t) s_t$. We assume, furthermore, that spending on education (e_t) and time spent with children (lch_t) creates skills and knowledge (h_t) among individuals in the child cohort through the following process (Eq. (3)):

$$ch_t h_t = a_{h,t} lch_t^{\theta} (e_t)^{1-\theta} \tag{3}$$

and these skills become, through the following process (see Eq. (4)), a human resource (ha_t) that already supports the agent's position in the labor market:

$$ha_t = \kappa \left(\frac{1}{18} \sum_{s=t-18}^{s=t-1} h_s \right) + (1 - \delta_h) ha_{t-1}. \tag{4}$$

The representative firm uses labor and capital to produce output in a perfectly competitive environment. The production function takes the following form:

$$Y_t = a_t K_t^{\alpha} (ha_t L_t)^{1-\alpha}, \tag{5}$$

where $K_t = N_t k_t$, and $L_t = N_t l_t$. The pension system converts contributions collected from representative agents into pension payments, while also able to accumulate debt:

$$N_t \tau_t w_t h a_t l_t + D_{t+1} = P_t tr_t + (1 + r_{t+1}) D_t, \quad (6)$$

where P_t is the number of retirement-age agents, tr_t is the pension premium and D_{t+1} is the accumulated debt. Markets clear. In the market for goods and services, the quantity of goods and services produced is equal to the sum of consumption by children, active agents, and retired persons, as well as investment and the value of community services financed to develop skills. For simplicity, the consumption of pensioners is equal to the value of the pensions received. Formally this condition is written as

$$Y_t = (1 + ch_t x) N_t c_t + P_t tr_t + I_t + N_t e_t, \quad (7)$$

where,

$$I_t = K_{t+1} + (1 - \delta) K_t. \quad (8)$$

The asset market will be in equilibrium if the savings of the representative agents finance the purchase of capital assets and the loans taken by the pension fund (Eq. (9)),

$$N_t s_t = K_{t+1} + D_{t+1} \quad (9)$$

and if capital accumulation can provide exactly the same return as asset accumulation, i.e.

$$1 + r_{t+1} = r_{t+1}^K + (1 - \delta), \quad (10)$$

where r_{t+1}^K is the real rental rate of capital (Eq. (10)). The real wage and real rental rate in the market for production factors are such that the demand for factors of production is exactly equal to the supply of factors of production. The model consists of the behavioral equations derived from equations (1)- (3) and (5), and equations (4) and (6) to (10).

RESULTS

Our model simulated 4 scenarios, projecting GDP per working-age person and the pension balance up to 2080. The 'Baseline case' would hold if there were no change in the value of the main parameters of the pension system, i.e. the retirement age, pension contribution and replacement rate shown in Table 1 would hold in the following decades, while the demographic indicators (growth rate of the working-age population and the number of children and elderly per working age) would evolve as estimated by the UN (2024) median projection. For both countries, we find that the pension balance deficit as a share of GDP is expected to triple in Hungary and increase 4.5 times in Korea compared to its 2024 level (see Figure 3 and Figure 4).

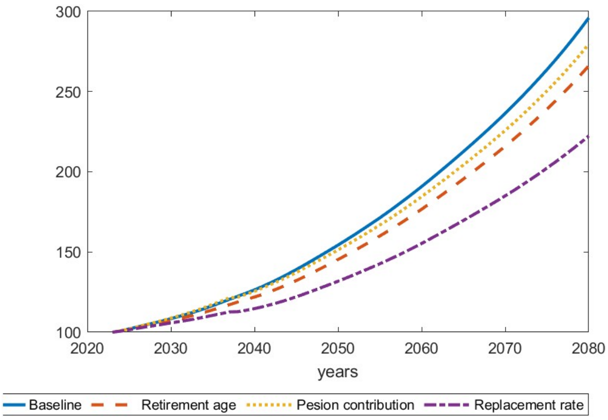


Figure 3: The projected pension balance deficit as a share of GDP relative to 2024 level (2024=100), Hungary, 2024-2080

Source: Own simulation with our model.

The other three cases illustrate the expected impact of three different pension reforms ceteris paribus, taking effect after 15 periods, but with economic agents already informed in advance of the change (see Fig.3 and Fig. 4.) The '*Retirement age*' case in the figures shows an increase in the retirement age from the current 65 to 66 in Hungary and from the current 63 to 64 in Korea. In the case of '*Pension contribution*', the pension contribution increases from 10% to 15% in Hungary and from 4.5% to 6.75% in Korea, in both cases by 50%. In the '*Replacement rate*' version, the ratio of the pension transfer paid to an elderly person to the average salary decreases from 52.4% to 42.4% in Hungary and from 31.2% to 21.2% in Korea.

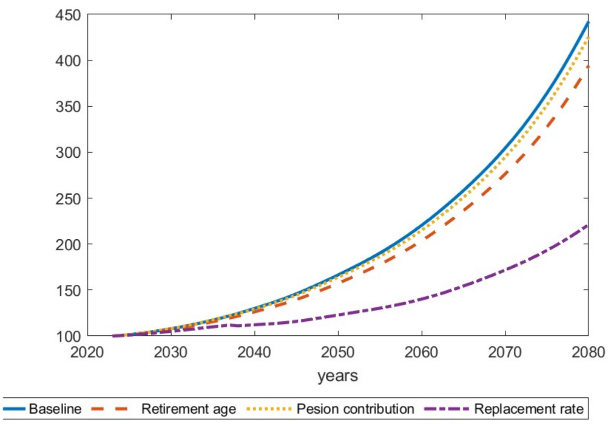


Figure 4: The projected pension balance deficit as a share of GDP relative to 2024 level (2024=100), Republic of Korea, 2024-2080

Source: Own simulation with our model.

CONCLUSIONS AND FURTHER RESEARCH

We see that all policy reforms mitigate the deterioration in the pension balance to GDP ratio, but especially in Korea, the positive impact of the reduction in the replacement rate is prominent. However, this is not an acceptable solution because of the reduction of the welfare of pensioners; in addition, currently, Korea has the highest share of pensioners living below the poverty line among OECD countries. This leads us to conclude that in Korea, a pension reform driven by a gradual increase in the official retirement age combined with an increase in pension contributions is unavoidable, while in Hungary, given the already high tax and contribution rates on labor, it is mainly the increase in the retirement age that could make the biggest contribution to improving the pension balance. In Korea, the dynamically deteriorating demographics are present, and in Hungary, the current deficit in pension funds is of real concern.

As a continuation of the research, we would like to include all pension pillars for Korea in the model and quantify such a combination of the pension systems' parameters that would provide a sustainable pension balance in the long run for both countries.

REFERENCES

B. Baksa, B. Bonthuis, S. Guo, and Zs. Munkacsi. Parametric Pension Reform Options in Korea. IMF Working Papers 2024/223 (Washington: International Monetary Fund), 2024.

Ki-H., Choi and Shin, S. Population aging, economic growth, and the social transmission of human capital: An analysis with an overlapping generations model. *Economic Modelling,* 50: 138–147, 2015. doi: http://dx.doi.org/10.1016/j.econmod.2015.05.015

European Commission. Employment, Social Affairs Inclusion. Hungary - Old-age Benefits. Retrieved Dec 7, 2024, from https://ec.europa.eu/social/main.jsp?catId=1113&intPageId=4581&langId=en

C. I., Jones. The end of economic growth? Unintended consequences of a declining population. *NBER Working Paper* No. 2665, 2020. doi: https://doi.org/10.3386/w26651

E., Kim, J.D. H., Geoffrey and C., Lee. Impact of educational investments on economic losses from population aging using an interregional CGE-population model. *Economic Modelling*, 54: 126-138, 2016.doi: https://doi.org/10.1016/j.econmod.2015.12.015

E., Kovács, Á., Vaskövi. Living Longer. Working Longer? - Life Expectancy and Retirement Age Trends in OECD Countries. *ECMS 2019 33rd International ECMS Conference on Modelling and Simulation*: 103-108, 2019.

R, Lee. Macroeconomics, Aging, and Growth. In B.-S. et al. (Ed.), Handbook of the Economics of Population Aging, Elsevier 1:59–118, 2016. Elsevier.

N., Maestas, K. J., Mullen and D., Powell. The effect of population aging on economic growth, the labor force, and productivity. *American Economic Journal: Macroeconomics* 15(2): 306–32, 2023. doi: http://doi.org/10.1257/mac.20190196

OECD. OECD Reviews of Pension Systems: Korea, OECD Reviews of Pension Systems, OECD Publishing, Paris, 2022. doi: https://doi.org/10.1787/2f1643f9-en

OECD. Pensions at a Glance 2023: OECD and G20 Indicators, OECD Publishing, Paris, 2023. doi: https://doi.org/10.1787/678055dd-en

OECD. OECD Economic Surveys: Hungary 2024, OECD, Paris, 2024a. doi: https://doi.org/10.1787/795451e5-en

OECD. OECD Economic Surveys: Korea 2024, OECD Publishing, Paris, 2024b. doi: https://doi.org/10.1787/c243e16a-en

OECD. Strengthening the Hungarian Pension System. 2024c. https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/structural-reforms/country-tailored-policy-reforms/Strengthening-the-Hungarian-Pension-System.pdf

OECD. International Migration Outlook 2024, OECD Publishing, Paris, 2024d. doi: https://doi.org/10.1787/50b0353e-en.

ONYF. Country Fiche on Pension, 2017. Retrieved Dec 7, 2024, from https://ec.europa.eu/info/sites/default/files/economy-finace/final_country_fiche_hu.pdf.

E.T., Varga: The Impact Of The Tax Relief To Families On Household Income In Hungary. Who benefits the most from the family allowances? ECMS 2023 Proceedings, edited by Enrico Vicario, Romeo Bandinelli, Virginia Fani, Michele Mastroianni 2023-06-23 | Conference paper DOI: 10.7148/2023-0100

P., Vékás. *Az élettartam-kockázat modellezése*. Budapest, Magyarország, Budapesti Corvinus Egyetem (2019), 176 p. 2021. ISBN: 9789635037681

DATA SOURCES

HCSO (Hungarian Statistical Office) (2025): 22.1.1.6. Live births, total fertility rate. Online Database. Hungarian Central Statistical Office, Budapest, Hungary. Retrieved Jan 10, 2025, from https://www.ksh.hu/stadat_files/nep/en/nep0006.html.

KOSIS (Korean Statistical Information Services). 3. Vital Statistics of Korea. Statistical Database. Statistics Korea, Daejeon, Republic of Korea. Retrieved Jan 10, 2025, from https://kosis.kr

OECD. OECD Data Explorer. Life expectancy Retrieved Jan 10, 2025, from https://data-explorer.oecd.org/

UN (United Nations). Probabilistic population projections based on the world population prospects 2024 Online Edition; 2024 Nov; Department of Economic and Social Affairs, Population Division, United Nations. Retrieved Dec 10, 2024, from http://population.un.org/wpp/

World Bank. World Development Indicators. Fertility rate, total (births per woman) Retrieved Jan 10, 2025, from https://data.worldbank.org/indicator/SP.DYN.TFRT.IN

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