REGULATORY PROBLEMS IN LONGEVITY RISK MANAGEMENT IN THE POLISH PENSION SYSTEM

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Abstract

Life expectancy has been increasing since the XX century and the first two decades of the XXI century globally, especially in developed OECD countries, including Poland. But future trends of lifespan for different countries and demographic cohorts remain uncertain. One of the many economic and social consequences of this process is the increase in the longevity risk in social security systems.

The longevity risk (life expectancy risk) is the risk of living longer than expected. On an individual basis, the realization of longevity risk can cause exhaustion of pension savings and often poverty for elderly people. Group (aggregate) longevity risk – the risk that a certain age cohort will live longer than expected – is relevant for public and private institutions which are obliged to pay lifetime annuities.

This article focuses on the issues of managing longevity risk in the pension system in Poland, in particular – the construction of public and supplementary pension systems and its ability to adapt to the challenges associated with longevity risk.

Keywords: *longevity risk, demographic risk, pension systems, risk management*

1. INTRODUCTION

There has been an ongoing process of extraordinary transformation on a global scale, which is unprecedented in the history of mankind. In the following decades of the 20th and 21st centuries, the process of demographic population aging continued. The number of older people has been increasing both in absolute numbers and in proportion to other age groups (people at both working and pre-working age). Demographic forecasts predict that in the middle of this century, the number of people aged 60 and more will amount to 2 billion (out of 8 billion of the world's total population) and for the first time in the history of mankind will exceed the number of children (up to 15 years of age) living in the world (McWilliam, Timothy &Thomas 2019). Demographic aging of the population, most advanced in economically developed countries, is the result of two long-term demographic trends: an increase in average life expectancy and a decrease in fertility.

The increase in life expectancy is a process that should be considered positive, progress, an effect of progressing civilization. Meanwhile, the literature on the subject in the field of pension economics, management science, or social security law, contains multiple instances of the term aging crisis, which is most often used to collectively define both the pension crisis and the health care crisis. As N. Barr and P. Diamond (2010) rightly note, this is a kind of paradox. The fact that "People are living longer in most countries, often considerably longer, and are expected to live even longer in the future" (Diamond & Barr 2010, p. 3) is a positive phenomenon. However, it cannot be ignored that there are serious risks and challenges associated with the demographic aging of the population.

The increase in the number of older people living longer and longer and demographic changes related to the aging of the population contribute not only to **demographic risk**, well recognized in the literature, but also to threats to the financial stability of social security systems (especially pension and health care systems). It also provides new opportunities related to the increase in demand for goods and services for the elderly (silver economy).

A relatively lower than the demographic risk, although gradually growing interested - at least in terms of Polish scientific literature in the field of social policy theory, pension economics, and management

sciences - remains another risk also related to demographics: the **longevity risk**, sometimes also called **life expectancy risk**, or and uncertainty about future life expectancy.

Determining the longevity risk as a risk of longer than expected life expectancy requires clarification. It is difficult to disagree with the opinion of M. Bartkowiak that "this concept may provoke resistance due to linguistic reasons"(Barkowiak 2019, p. 5). After all, according to common opinion, long life is desirable. There is no doubt, however, that if an individual or a group reaches an age longer than expected, this may also trigger certain risks of economic, financial, and social nature. The effects of this risk affect various groups of stakeholders (public and private institutions obliged to pay annuities, people living longer than expected and their families, local communities, and the state). As far as T. Crawford, R. de Haan, and Ch. Runchesey (2008) is concerned, that longevity risk is "one of the biggest and least understood risks for insurance and reinsurance companies, pension plan sponsors and government institutions". The realization of this risk may also carry negative consequences for individuals and households composed of older people.

The longevity risk is related to demographics, but also to the **imperfection of life expectancy forecasting** - both in individual and in a group, aggregated dimension, concerning entire demographic years (cohorts).

Individual longevity risk consists in the fact that given individuals will outlive their retirement savings.

Errors made by the individual as to their life expectancy may lead to the following general consequences:

• depletion of resources (financial, property) accumulated for old age (savings, additional pension schemes, etc.) resulting in a decrease in the standard of living, inability to satisfy or insufficient satisfaction of life and social needs, including those related to health care, in extreme cases - poverty in old age;

• inability to leave any material legacy for heirs;

• too sparse use of savings, investments, or assets accumulated in old age and leaving excessive, larger than intended resources after death.

Differences between the life expectancy of a given individual and the actual life expectancy, which no one can predict in advance with 100% certainty, can and often do cause the wrong distribution of investments over time and making suboptimal decisions regarding the division of the gathered income in the life cycle between the current consumption and savings (consumption deferred in time).

Aggregate longevity risk, also known as systematic or trend risk, applies to entire populations. It consists of the fact that in a given cohort (demographic year), the average life expectancy will be longer than expected. Combined, individual, and aggregated longevity risks contribute to **total longevity risk**.

Individual or group longevity risk is the opposite of **mortality risk**, which is the risk that an individual or group will live longer than expected.

Erroneous or not sufficiently precise forecasts of demographic trends, and underestimation of survival rates (realization of the aggregated longevity risk), all result in increased liabilities towards people covered by lifelong benefits from public or private institutions. This applies to both public liabilities of institutions in the social security system (e.g. ZUS in Poland) and liabilities of private financial institutions (e.g. life insurance companies, occupational pension schemes, especially those based on the defined benefit formula and paying lifelong benefits). This can and often does carry serious negative financial consequences for these institutions. For example, in the US, there have already been cases of bankruptcy of companies offering their employees occupational pension schemes with defined benefits (predetermined in proportion to earnings) and guaranteed lifetime benefits. Bankruptcies of life insurance companies with annuity policies, driven by the realization of longevity risk, have also been recorded.

In the case of public institutions, it also has a significant impact on the condition of public finances. The state is the ultimate guarantor of the payment of pension benefits from the public pension system, but

also perturbations related to the possible insolvency of private financial institutions as a result of the aggregate (systematic) longevity risk indirectly affect the condition of public finances.

As G.Trzpiot (2015) aptly puts it, "the average value of life expectancy has been increasing and even a slight change in life expectancy can cause serious insolvency problems for pension systems and insurance companies. The payout horizon also changes. Longevity risk is a risk that a pension fund or a life insurance company could not previously take into account in their activities".

The level and variability of life expectancy, as well as errors in its forecasting, which constitute the sources of longevity risk, significantly affect the decisions and behavior of individuals and groups, economic growth in the long term, the way the social product (GDP) is divided between generations at working age and post-production, social transfers, obligations of the social security system and the health care system, incentives for additional saving for retirement purposes, as well as investments in education and human capital in general, undertaken by public authorities as part of social and economic policy and activities undertaken by the private sector (e.g. employment policy and age management in the workplace, supply of products and services for the growing population of the elderly). These are issues of fundamental social and economic importance.

The specificity of the longevity risk lies in the fact that it is **long-term, grows gradually, and the effects of its realization are deferred in time**. Managing this risk requires making and, if necessary, modifying assumptions about mortality and life expectancy in the very long term. For example: if a person starts work and becomes a participant in the pension system at the age of 25, and dies at an old age, living to be 80-90 years old, then - as experts from the Working Party on Private Pensions (WPPP) operating within the OECD (2014) point out - the assumptions and projections of future mortality must cover at least 60 years.

The process of demographic aging of the population and the related increase in demographic risk and related, but separate, longevity risk has forced the search for solutions to manage these types of risk. The most commonly used solutions can be divided into the following three groups:

1) reforming the pension system (parametric, internal, and systemic (structural) reforms)

2) distributing the pension benefit burden between the insured person and public structures,

3) transferring longevity risk elements to financial markets.

However, longevity risk management, which is complex and multifaceted, cannot be limited only to institutional changes (incidentally, reversible - as evidenced by the fate of the Polish systemic pension reform of 1999). Also, the most innovative solutions related to the transfer of longevity risk through specific instruments and financial markets encounter many obstacles and limitations. In the management of longevity risk – in addition to the legal, institutional and economic, and fiscal solutions used in various countries in the field of pension security and financial market instruments used to reduce individual and group (aggregated) longevity risk – **psychological, social and cultural factors also play a very important role**. It turns out that the individual longevity risk may be higher or lower for people from the same demographic age group (cohort), whose professional career and income in the life cycle have been at a similar level. Some of them made erroneous or at least suboptimal decisions, e.g., regarding additional savings and investments with a view to financial security in old age, and, reaching old age, they conclude that additional resources have run out, while others, on the contrary, live in relative abundance and can fully realize their needs during the "autumn of life" period.

2. MATERIALS AND METHODS

The article makes use of literature method, comparative analysis, and statistical methods. Quantitative data on demographic trends in the world and in the European Europe (including Poland) has been based on databases of the World Bank (World Bank), OECD, Eurostat, and the Polish Central Statistical Office (GUS).

3. RESULTS

3.1. Demographic determinants of longevity risk

The WHO report titled "Aging and Health" shows that on a global scale, already in 2020, the number of people aged 60 and older exceeded the number of children aged up to 5. Already in 2030, 1 person in 6 living around the world will be 60 years of age or older. By 2030 the share of people aged 60+ in the world's population will increase from 1 billion to 1.4 billion, and by 2050 - to 2.1 billion people. It is expected that between 2015 and 2050 the share of people aged 60+ in the world's population will almost double - from 12% to 22%. In 2050, 80% of older people will live in middle and lower-income countries.

“People continue to live longer and more years in good health. Global life expectancy at birth increased from 66.8 years in 2000 to 73,3 years, and healthy life expectancy (HALE) increased from 58.3 years to 63.7 years” (WHO 2022, p. VII).

The long-term forecasts prepared for the international organizations of the UN and the OECD demonstrate that even though the process of demographic aging of the population in different countries starts at different levels and proceeds at a different pace, it remains global, but in Europe, it is taking place the fastest. Its economic and social effects are already felt or will be felt in the next decades of the 21st century by all the countries of the world.

In 2021, the differences between the countries with the highest life expectancy from the day of birth amounted to approx. 33.4 years. For example, in Australia and Japan, those born that year could expect to live to an average of 85 (average for both sexes), while those in central Chad and Nigeria could expect to reach only 54. In 2050 this spread is projected to narrow, with a global average life expectancy from birth of 77.2 years, Europe and North America projected 83.8, Australia and New Zealand 87, and Sub-Saharan Africa respectively – 66.7 years.

The process of demographic aging of the population also applies to the countries of the European Union. In the European Union, the elderly already have a significant share in the structure of the population of the EU-27 countries (20.0% in 2018), a total of approx. 89 million, of which 51 million were women (57%) and 38 million men (42%). It is expected that in 2060 the number of the elderly in the EU-27 will increase to 131 million, of which 72 million will be women (55%) and 59 million (45%) men.

Over the past 50 years, life expectancy at birth has increased by 10 years for both men and women. In 2020, in the EU member states, further life expectancy at birth for men and women together amounted to 80.4 years (0.9 years less than in 2019, before the COVID-19 pandemic), with 83.2 years for women, and for men - 77.5 years. For men who turned 65 in 2020, life expectancy in the EU-27 is 18.1 years, and for women, it is 21.6.

In 2020, in Poland, the life expectancy of a male infant was 72.6 years, while for female infants it was 80.7 years. Compared to the previous year, this indicator deteriorated (as a result of the COVID-19 pandemic), and for men, this decrease was higher than for women (by 1.5 and 1.1 years, respectively). In 2020 a man aged 60 had 17.9 years of life ahead of him, and for women, the average life expectancy - according to the Central Statistical Office - was 23.2 years. The increase in the average life expectancy in Poland in the long term is illustrated in Figure 1.

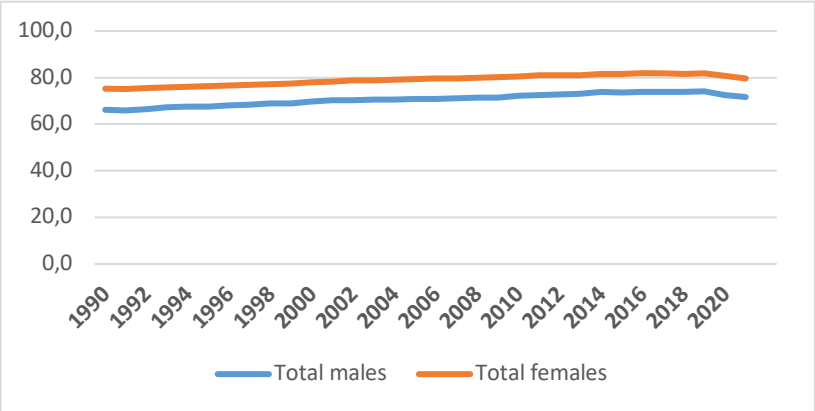

Fig.1. Life expectancy at birth of men and women in Poland 1990-2020*

*In 2020, 2021 and 2022, during the COVID pandemic, life expectancy at birth in Poland expectancy in Poland temporarily decreased. The current data from 2023 show a slight increase of life expectancy in Poland after the period of pandemic

Source: Central Statistical Office in Poland <https://stat.gov.pl/en/topics/population/life-expectancy/life-expectancy-in-poland,1,3.html>

It is worth noting that the increase in life expectancy has occurred for both men and women, but the difference between women was still maintained (they live statistically longer). There are also visible differences between the inhabitants of towns and villages.

In addition to the average life expectancy, a very important indicator - both from the point of view of social policy and longevity risk management in pension systems - is the average healthy life expectancy (*Healthy Life Years, HLY*), also referred to as the indicator of disability-free life expectancy (*Disability Free Life Expectancy - DFLE*). Extending life expectancy in health is one of the main goals of social policy (including health policy) in many countries, including Poland. On the other hand, it is an important parameter that should be taken into account in managing longevity risk in pension systems (cf. Table 1).

Table 1. Healthy life expectancy at birth (HLY_0) and percentage of healthy life (HLY_0/e_0) in 2021

	Men		Women	
	Healthy life expectancy	Percentage of healthy life [%]	Healthy life expectancy	Percentage of healthy life [%]
Poland in total	**59,1**	**82,4**	**63,1**	**79,2**
Urban	59,2	82,2	63,3	79,4
Rural	59,0	82,7	62,8	78,9
Lower Silesia	58,7	82,3	63,0	79,2
Kuyavian-Pomeranian	59,2	83,1	62,6	79,4
Lublin	58,3	81,7	62,1	78,1
Lubusz	60,1	85,2	64,5	81,7
Lodz	58,5	82,9	62,6	79,2
Lesser Poland	59,5	81,0	63,6	78,5

Source: Central Statistical Office [2022], Healthy life expectancy in 2021,https://stat.gov.pl/obszary-tematyczne/ludnosc/twarznie-zycia/twarznie-zycia-w-zdrowiu-w-2021-r-,5,2.html [access: 12.12.2022].

Important data for the assessment of the age risk level is also provided by the analysis of the structure of the population, taking into account age groups and gender (Table 2).

Table 2. Amount and structure of Poland's population in 2021

Total population (in thousands)	38 080	
By age groups (in thousands)	Men	Women
15-64	12 510	12 491,3
65+	2 903	4 345, 7
65-69	1 130,3	1 387, 4
70-74	843,6	1 156,60
75-79	418,1	661, 8
80-84	283,6	552, 9
85 +	227	587, 0
Old-age dependency ratio	24,3	54
Old-age dependency ratio for the entire population (men and women combined)	38,2	
Median age (middle age)	40.4 years	43.6 years
Median age (middle age) for all population (men and women combined)	42 years of age	

Remarks: The above summary of statistical data takes into account the results of the 2021 National Census.

Source: own study based on: Central Statistical Office [2022], Own elaboration based on statistical data of the Central Statistical Office, Subject area: Population <https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc>

Analyzing the data from tables 1, 2, and figure 1, the following phenomena and demographic trends can be observed:

– the average life expectancy of women is longer than that of men (as in other countries of the world);

– the healthy life expectancy rate in 2021 was higher for women than for men;

– men spend most of their lives without disabilities;

– although men are expected to have a shorter life expectancy, they will live most of it without a disability;

– there is regional variation in life expectancy,

– while there is a slight predominance of men in the working-age population in Poland, starting from the age of 65+, women dominate in subsequent age groups and they are more exposed to individual longevity risk.

3.2. Construction of the pension system in Poland from the point of view of longevity risk management

The pension system in Poland has been subjected to constant changes aimed at improving its functioning. Anticipating demographic trends and noticing the shortcomings of the existing solutions, radical changes of the pay-as-you-go system was introduced. Not only the individual parameters of pension systems have changed (e.g., the formula for calculating benefits, but also its entire structure.

The year 1999 marked the introduction of comprehensive, systemic pension reform, one of its main objectives being the division of risk between the financial and the labor markets by introducing a three-

pillar structure, and in particular, a second capital-funded pillar and private pension funds (called "OFE") operating within it. A mixed PAYG-funded scheme was created. In this scheme, the first pillar (administered by the Social Insurance Institution) is financed by current pension contributions of the working generation (the so-called generational contract), and the second pillar is composed of the pension savings of the working generations invested in the financial market. Pension contributions in Poland are relatively high and amount to 19.52% of gross income, of which the employer pays 9.76% and the remaining 9.76% is paid by the employee. In the accumulation phase of pension capital, the accumulated capital is recorded in the form of pension benefits (the first individual retirement account in the Social Insurance Institution confirming the state's commitment to pay future benefits, which will be financed by successive generations of workers) and financial capital (assets accumulated in pension funds, recorded in the second individual account, with coverage in financial instruments of a specified market value purchased with part of the contributions transferred to the second pillar).

Diversifying sources of future pension funding was supposed to (according to the reform's creators) reduce the risk to the long-term stability of the pension system. Whilst the first pillar (PAYG) is more sensitive to the risk of demographics which increases with the aging of the population (an increase in the number of people receiving pension benefits at retirement age to the contributors of working age) the financed pillar is subject to different (demographically non-correlated) kinds of risk (including investment risk). Both the PAYG and the funded pillar are not immune to aggregate longevity risk. The second significant change was the replacement of the formula for calculating benefits – a transition from a defined benefit (DB) to a defined contribution system (DC), leading to the individualization of benefits (equivalence of benefits to the contributions, a departure from the redistribution of income in a given generation of retirees). Diversification, however, was not only applied to the phase of capital accumulation but also the phase of its consumption (decumulation), which carries the risk of longevity. According to the initial assumptions of the pension reform of 1999 the payment of benefits from capital accumulated in the second pillar of the pension system was to be dealt with by pension institutes (created especially for this purpose), which would not only pay benefits under the second pillar but also multiply the accumulated capital and invest it in the low-risk financial instruments. However, such pension institutions never came into existence. For 15 years the pension reform has not been completed because there was no legislation regarding the payment of pensions from the second pillar. The payment of the total pension funds accumulated in the first and second pillars lies in the hands of the Social Insurance Institution. A lifetime pension (annuity) remains the only available product. What is more, the funds accumulated in the second pillar in the phase of capital accumulation will be gradually transferred to the Social Insurance Institution 10 years before a person retires (these funds will cover the current payment of benefits for the previous generation of retirees) in exchange for pension rights recorded in the participant's account on a special sub-account valorized according to different regulations than the rights recorded in the first pillar.

Today, the Polish pension system consists of three pillars (see table 3).

Table 3. Current design of the Polish pension system in 2023

Pillar I	Pillar II	Pillar III
• account in the Social Insurance Institution (SII)	• sub-account at the SII or sub-account at the SII and Open Pension Fund (OPF) account	• Individual Pension Accounts (IKE), • Individual Pension Assurance Accounts (IKZE), • Employee Pension Scheme (PPE) – voluntary occupational pension schemes, • Employee Capital Plans – quasi-obligatory* occupational pension schemes (PPK)

*PPK (Employee Capital Plan) is organized in automatic-enrolment form; employers are obliged to run and co-finance such a program for their employees, while employees have the right to opt-out (resign) – from the point of view of employee's participation in PPK is voluntary.

Source: Own elaboration

The first and the second pillar of the pension system are compulsory and financed from the pension contributions of the employed (calculated and collected on remuneration). In the mandatory part of the pension system, a pension contribution of 19.52% of the so-called basis of calculation, i.e., gross salary, is transferred. Part of this contribution, 12.22%, goes to the first pillar of the participant's account at the Social Insurance Institution. The funds accumulated in the SII are allocated to the current payment of pensions (pay-as-you-go system). The remaining 7.3% of the premium goes to the 2nd pillar—either entirely to the participant's sub-account at the SII, or 4.38% to the sub-account at the SII, and 2.92% to the account in the Open Pension Fund. The funds accumulated in the SII sub-account in the 2nd pillar are subject to valorization as in the 1st pillar, while the funds accumulated in the OPF are adjusted by the rate of return on investment on the capital market (capital system).

The third pillar of the pension system is voluntary. The purpose of this part is to collect additional and private savings for the period of professional inactivity.

From the point of view of longevity risk management, the pay-out phase is important. The literature on retirement economics is dominated by the subject that only the payment of benefits in the form of a life annuity protects against the risk of longevity. As D. Blake points out, the very definition of a pension product includes the assumption that it ensures the lifetime payment of benefits. Different rules for the pay-out phase in the public pension system (pillar I and pillar 2), and in additional pension schemes (pillar 3) are characterized in Table 4.

Table 4. Form of payment of benefits in the Polish pension system

Pillar I	Pillar II	Pillar III
Life Annuity (adjusted to inflation and partly to an average wage increase)	Life Annuity (adjusted to inflation and partly to an average wage increase)	*1) Individual Pension Account (IKE)* - Lump sum payment (from the age of 60 tax exempted) *2) Individual Pension Assurance Account IKZE)* - Lump sum payment (from the age of 65 tax exempted) *3) Employee Retirement Plan (PPE)* - Lump sum payment (from the age of 60 tax exempted) 4*) Employee Capital Plan (PPE)* - 25% lump sum, the rest in form of programmed withdrawal (120 payments in 10 years), from the age of 60 tax exempted

Source: Own research

As can be seen from the above list, only the mandatory public pension system in Poland, covering the majority of employees[1], provides for the payment of benefits in the form of an annuity. None of the pension products available in the third, voluntary pillar of the pension system (individual pension schemes: IKE and IKZE and occupational pension scheme PPE) guarantees lifetime payment and therefore does not protect against individual longevity risk. (Szczepański 2016). The new occupational pension scheme – Employee Capital Plan (PPK), introduced in 2019, offers programmed withdrawals only for 10 years after reaching the age of 60. It is not sufficient protection against longevity risk.

The current public pension system in Poland has based mostly on a non-financial defined (NDC) formula and Pay-As-You-Go financing methods (so-called social contract – current benefits for pensioners paid out of current contributions of the working age generation). The funded pillar of the public pension scheme plays a marginal role. All supplementary pension plans operating in Poland are based on a purely defined contribution formula. This means full exposure of the individual saver to many risks, such as investment risk, inflation risk, liquidity risk, market timing risk, bequest risk, risk of outliving one's savings (individual longevity risk), risk of a substantial decline in consumption (Rutecka-Góra 2020).

Whilst the first pillar (PAYG) remains more sensitive to the risk of demographics which increases with the aging of the population (an increase in the number of people receiving pension benefits at retirement age to the contributors of working age) the financed pillar is subject to different (demographically non-correlated) kinds of risk (including investment risk). Both the PAYG and the funded pillar are not immune to aggregate longevity risk. A more comprehensive summary of the different types of risk in PAYG and fully funded pension schemes is presented in Table 5.

Table 5. Comparison of risk in the pay-as-you-go and fully-funded pension systems

Threats and risks	– demographic risk – macroeconomic risk (especially: high inflation risk and unemployment risk) – moral risk manifesting itself in a tendency of premature occupational deactivation to gain benefits – political risks associated with unjustified redistribution of resources to gain the political support of advantaged groups – longevity risk	– demographic risk (less than that for PAYG) – capital market crisis – inadequate investment policy – macroeconomic risk (especially: high inflation risk and unemployment risk) – longevity risk

Source: own elaboration.

4. RESULTS AND DISCUSSION

In the current public pension system in Poland, final benefits paid in form of life annuity are dependent only on the sum of valorized contributions and life expectancy. Such a system only partly protects against individual longevity risk. Due to population aging (fewer and fewer people of working age contributing to pension systems to more and more people of post-working age receiving pension benefits), the replacement rate (relation of the pension benefit to the last salary) has been decreasing. According to the projections of OECD, in 2050 the dependency ratio in Poland will only be about 40% (in comparison to 51% in 2021).

The current design of the Polish pension system does not protect its participants against individual longevity risk. Only the public pension system with payments in form of life annuity protects against longevity risk, but at a low level, due to decreasing adequacy of pension benefits. None of the additional

[1] Representatives of selected professions such as uniformed services, judges, prosecutors and farmers make use of separate pension systems).

pension schemes – both individual and occupational – protect against longevity risk. It is necessary to change the design of these additional pension schemes. They should offer life annuities instead of lump sum payments or programmed withdrawals. Instead of obligatory annuitization of additional pension schemes some incentives from behavioral economics could be used – for example, making life annuity a default option for all pension products (IKE. IKZE, PPE, and PPK), and developing of annuities market offered by private companies (especially life insurance companies), which functions in Poland in a rudimentary form.

Regulatory changes are necessary for additional pension schemes in Poland. Only financial products with the default option of life annuity payments can be treated as pure pension products (not only savings or investment products) and provide real protection against (individual) longevity risk.

REFERENCES

1. Barr& N., Diamond, P. 2010, *Pension Reform. A Short Guide*. Oxford University Press, New York.
2. Bartkowiak, M. 2019, *Modelowanie śmiertelności i transfer ryzyka długowieczności* [Mortality modeling and longevity risk transfer], Wydawnictwo UEP, Poznań.
3. Crawford, T., de Haan, R. & Runchey, Ch. 2008, *Longevity Risk Quantification and Management. A review of Relevant Literature*, November, Society of Actuaries, viewed 15 March 2023, <https://www.soa.org/globalassets/assets/Files/Research/Projects/research-long-risk-quant-rpt.pdf>
4. OECD 2014, *Mortality Assumptions and Longevity Risk*. Implications for pension funds and annuity providers, <https://search.oecd.org/daf/fin/private-pensions/mortality-assumptions-and-longevity-risk-9789264222748-en.htm>
5. Population, <https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc>, Polish Central Statistical Office (GUS).
6. Rutecka-Góra, J., 'Deficiencies in the supplementary pension market in Poland from the perspective of regulatory policy', Acta Scientarum Polonorum, no. 19 (2), pp. 51-59.
7. Szczepański, M., 'Managing Longevity risk in Pension system: The Case Study of Poland', Eurasian Studies in Business and Economics (Book series, EBES, vol. 5), DOI: 10.1007/978-3-319-46319-3_44.
8. Trzpiot, G. 2015. 'Wybrane determinant ryzyka długowieczności' [Chosen determinants of longevity risk], Studia Ekonomiczne. Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie, no. 223, pp. 225-237.
9. McWilliam,E., Howe, T. & Thomas, M. (2019), *Longevity risk*, 2nd edn, Risk Books, London,
10. World Health Statistics 2022. Monitoring health for the SDGs Sustainable Development Goals, World Health Organisation, <https://www.who.int/publications/i/item/9789240051157>