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GLOBAL AGING – THE NATURE OF LONGEVITY RISK

Abstract. In this paper we investigate the latest developments on longevity risk modelling. We first introduce longevity risk to allow for a better understanding of the related challenges in term of risk management from both a financial and insurance point of view. The article also provides a global view on the practical issues of longevity. Simultaneously, the development on the longevity has enhanced the need of capital markets as to manage and transfer the risk. Therefore, we also highlight future developments on longevity risk management from a financial point of view.

Keywords: longevity Risk, risk transfer, stochastic mortality, population dynamics.
JEL: J11, C18, C22, G19.

1. INTRODUCTION

The risk in the social sciences has different meanings. The economic research if we are talking about the risks, identifies the concept of choice, not the inevitable destiny. The risk is the result of uncertainty, and uncertainty is a source of risk. The uncertainty is defined as a state where they future capabilities of the tested characteristics (quantitative or qualitative) is not known

Uncertainty is also referred to future changes, which are difficult to estimate, or it is not possible to estimate the probability distribution of future events. Unknown risk is defined as that which would be achieved in the future, when it is possible to determine the future situation or the likelihood of those individual events is known Risk measurement and its reduction is possible if we well define the problem (Trzpiot 2008, 2011).

The risk of longevity (life expectancy) is a potential risk associated with increasing life expectancy of retirees and other beneficiaries of insurance policies. This is a significant risk to those who use to date income and savings. This is a potential problem of quality of life, in case of incomplete health and other age-associatedlimitations of people living longer than the average life expectancy.

The average value of life expectancy increases, and even a slight change in the value of life expectancy[1] can cause serious problems of insolvency for

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pension schemes and insurance companies. This phenomenon comes to higher than expected payment of pension and retirement funds and the payment of insurance companies[2]. The horizon of payments is also changed. Longevity risk is the risk that could not be previously taken into account in operations of a pension fund or life insurance (IMF, 2012).

The paper is organized as follows: first we present some important facts connected with global aging, next we describe different meaning and understanding of the longevity risk. We close this paper by looking for model risk which is connected with this important set of problems.

2. GLOBAL AGING

The economic and fiscal effects of an aging society have been extensively studied and are generally recognized by policymakers, but the financial consequences associated with the risk of people living longer than expected-longevity risk-has received less attention. Unanticipated increases in the average human life span (Figure 1) can result from misjudging the continuing upward trend in life expectancy, introducing small forecasting errors that compound over time to become potentially significant. This has happened in the past. There is also risk of a sudden large increase in longevity as a result of, for example, an unanticipated breakthrough in medicine. Although longevity advancements increase the productive life span and welfare of millions of individuals, they also represent potential costs when they reach retirement.

When Lee and Carter (1992) showed that their extrapolative model explained 93 percent of the variation in mortality data in the United States, it became the standard model for the longevity forecast literature and the preferred forecasting methodology for the U.S. Census Bureau and the Social Security Administration. Employing time-series analysis, the model estimates an underlying "mortality index" using variations in mortality data across different age groups over time. The index can then be used to forecast future longevity. In Table 1 and in Figure 2 we presents estimates of longevity trends.

The large costs of aging are being recognized, including a belated catch-up to the currently *expected* increases in average human life spans. The costs of longevity risk – *unexpected* increases in life spans – are not well appreciated, but are of similar magnitude. In Table 1 we present estimates that suggest that if everyone lives three years longer than expected now – the average underestimation of longevity in the past – the present discounted value of the

[1] This is an unknown parameter of the random variable.
[2] Sales of life insurance companies as an additional financial current income.

additional living expenses of everyone during those additional years will amount to between 25 and 50 percent of 2010 GDP. On a global scale, that increase amounts to tens of trillions of U.S. dollars, boosting the already recognized costs of aging substantially.

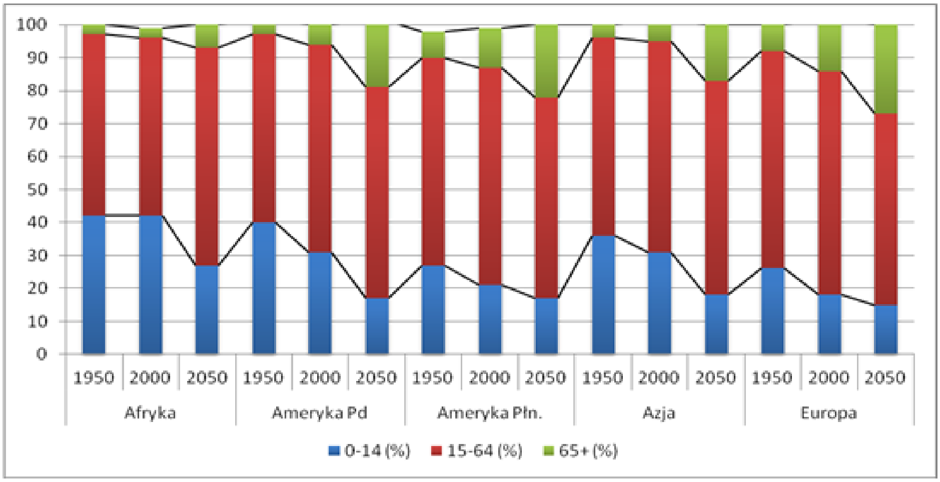


Figure 1. Change of the age structure, based on www.un.org/en

Table 1. Longevity Trends, 1970–2050

	Observed			Projected	
	1970–2010	Increase per year	Standard deviation	2010–2015	Increase per year
Change in life expectancy at birth					
US and Canada	8.2	0.20	0.14	4.3	0.11
Advanced Europe	8.6	0.21	0.13	4.7	0.12
Emerging Europe	1.1	0.03	0.36	6.8	0.17
Australia and New Zealand	10.8	0.27	0.27	4.9	0.12
Japan	10.8	0.27	0.23	4.6	0.11
Change in life expectancy at 60					
US and Canada	4.9	0.12	0.11	3.1	0.08
Advanced Europe	5.7	0.14	0.13	3.7	0.09
Emerging Europe	0.6	0.02	0.18	3.8	0.09
Australia and New Zealand	7.2	0.18	0.23	3.7	0.09
Japan	7.7	0.19	0.19	3.7	0.09

Sources: Humanity Mortality Database as of December 2011, IMF estimates.

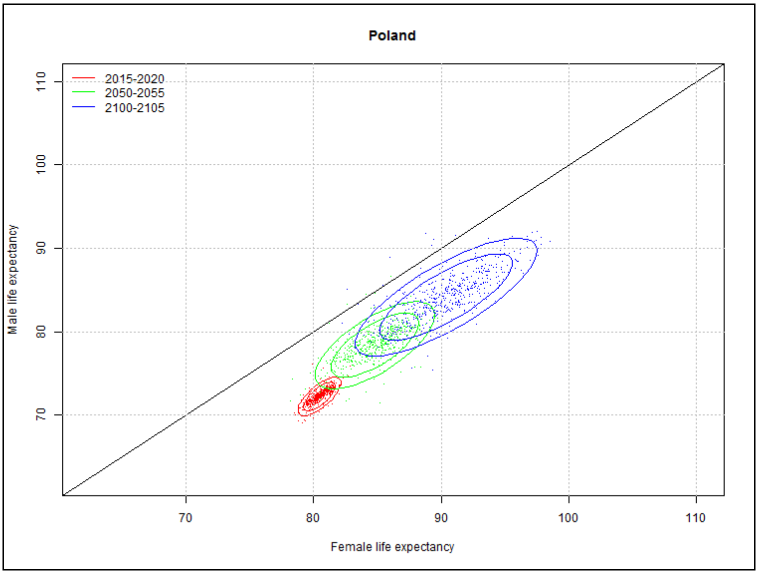


Figure 2. Change of the life expectancy in Poland, based on www.un.org/en

In most countries, the estimated present discounted value of required retirement income under current U.N. longevity assumptions for 2010–50 (Table 2, column 2) exceeds household total financial assets (Table 2, column 1). Gaps vary among countries, partly because of differing aging trends; they may also reflect individuals counting to varying degrees on income from social security schemes and on net housing wealth (which are excluded from the table because of data limitations). In Japan and Germany, for instance, the gaps between financial assets and potential liabilities are equivalent to between about 2 and 3½ times their respective GDPs in 2010, assuming again a range of replacement rates of 60 to 80 percent.

Table 2. Longevity Risk and Fiscal Challenges in Selected Countries (in % of 2010 nominal GDP)

Country	(1) Household Total Financial Assets (2010)	(2) Present Discounted Values of Needed Retirement Income	(3) General Government Gross Debt (2010)	(4) Gap: (1) – (2)	(5) Increase in Present Discounted Values Given 3-Year Increase in Longevity
1	2	3	4	5	6
United States	339	272 to 363	94	67 to –24	40 to 53
Japan	309	499 to 665	220	–190 to –356	65 to 87
United Kingdom	296	293 to 391	76	3 to –95	44 to 59

Table 2. (cont.)

Canada	268	295 to 393	84	–27 to –125	42 to 56
Italy	234	242 to 322	119	–8 to –88	34 to 45
France	197	295 to 393	82	–97 to –196	40 to 54
Australia	190	263 to 350	21	–73 to –161	36 to 49
Germany	189	375 to 500	84	–186 to –311	55 to 74
Korea	186	267 to 357	33	–81 to –170	39 to 52
China	178	197 to 263	34	–19 to –85	34 to 45
Spain	165	277 to 370	60	–112 to –205	39 to 52
Hungary	108	190 to 254	80	–82 to –146	34 to 45
Czech Republic	89	216 to 289	39	–127 to –200	36 to 48
Poland	88	160 to 213	55	–72 to –125	27 to 35
Lithuania	80	189 to 252	39	–109 to –172	34 to 45

Sources: National flow of funds accounts; national accounts; IMF (2011c); and IMF staff estimates.

3. NATURE OF LONGEVITY RISK

Longevity risk is the risk that the actual life span of individuals or whole populations will exceed expectations. We try to notice how we can understand longevity risks.

– Longevity risk as individuals outliving their financial resources (also called individual or idiosyncratic longevity risk);

– Longevity risk as mortality improving more than expected, or uncertainty about future mortality improvements (also called systematic, aggregate, or pooled longevity risk);

– Longevity risk as the additional cost to a society or, more narrowly, a pension system, when mortality improvements are underestimated;

– Longevity risk as the adverse consequences of living a long time.

3.1. Individual or idiosyncratic longevity risk

A common use of the term longevity risk is to describe the likelihood of an individual outliving his or her financial resources. Employing the term "longevity risk" here is an essential ingredient in building the case for the purchase of annuity products and other lifetime income solutions. Individual longevity risk that may cause them to outlive their financial resources "retirement ruin" (Trzpiot, Majewska 2015 a, b, c).

Typically, the discussion begins with an assertion about a retiree's life expectancy, and is followed by an assertion that there is a significant probability that the retiree will outlive his or her financial resources. This probability is then defined as longevity risk. We can represent individual longevity risk by a curve with wide variability. Used this way, longevity risk is an individual risk, also known as idiosyncratic longevity risk. It is distinct from systematic longevity risk, which is associated with the pooling of individual risks.

3.2. Systematic or aggregate longevity risk (pooled individual longevity risk)

Aggregate longevity risk is the risk that people on average live longer than expected. Assuming that individual longevity risks have been pooled, what remains is usually called systematic longevity risk (also called aggregate longevity risk or trend risk).

Systematic longevity risk is the risk that actual mortality experience of the population in question differs from what is expected. This difference arises from uncertainty associated with future mortality improvements. In the context of a typical mortality table, an individual life span may vary according to the table's probabilities of death. However, the mortality table itself changes each year in uncertain ways. The risk associated with uncertain future mortality tables is the systematic longevity risk. We can look for systemic risk: longevity risk has a very long tail, in line with the human expectancy. That is largely systemic risk which runs slowly over time (Trzpiot 2015).

3.3. Longevity risk as the consequences of underestimating mortality improvements

The response to this sense of longevity risk focuses on using robust life expectancy improvement assumptions in fiscal analysis, and on taking steps to lessen adverse financial impacts in case the life expectancy improves much more than expected.

(When we try to look as for insurance or financial market that will be a liability has a longevity risk exposure whenever cash owns are guaranteed for the lifetime of a recipient) This sentence is not clear Try to rephrase it, please.) As for retirees that will be the risk that the amount of money an individual saves for retirement might not be enough to sustain them, due to increased life expectancy – specific risk. Not only is this an important risk for most (life) insurers and pension funds, the resulting solvency margin will also be a part of the fair value reserve. The reason for this is that it is becoming the best practice for the quantification of the Market Value Margin to apply a Cost of Capital rate to the solvency capital necessary to cover for unhedgeable risks (Trzpiot 2014).

Hedging longevity risk is now an important element of risk management for many organizations (Table 3). The capital markets are developing as an alternative channel for longevity hedging: complementary to the insurance markets and provide additional capacity and potential for liquidity. Existing insurance/reinsurance capacity is small relative to the potential size of the market. We expect new capital which must be attracted to back longevity risk. Longevity offers an attractive risk premium, already exploited by annuity providers and pension insurers. It also offers diversification with respect to traditional asset classes and this diversification benefits even greater for life insurers.

Table 3. Commonly Perceived Risk: Insurers vs. Pension Sponsors

Risk Type	Insurance Company Description	Pension Plan Description	Pension Sponsor view of Risk
Investment Risk	Default risk on fixed-income investments and market value risk on equity type investments	Equity market	15%
Pricing Risk	Longevity Risk	Longevity	21%
Interest Rate Risk	Interest Rate and asset-liability management risk	Interest Rate Inflation	58%
Operational Risk	Operational Risk	Not mentioned in survey	Not mentioned in survey

Sources: Standard & Poor's Capital Model, 2010 Pension Risk Management Global Survey.

The life table is a decreasing sequence of the estimated number of people alive at date t and at given age *x* from an initial group of individuals.

– periodic life tables, based on the mortality experience of an entire population during a relatively short period of time, usually one to three years

– cohort (generation) life tables are based on mortality experience over the entire lifetime of a cohort of persons born during a relatively short period of time, usually one year.

Classical life tables are well-suited to quantify short-term mortality risk (death insurance): 1 to 5 years if no exceptional event (e.g.: a pandemic or a heat wave). Usually these tables are not relevant for long term longevity-based contracts as mortality rates are changing over time .

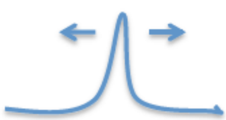
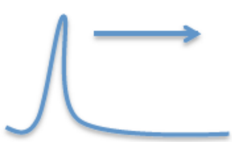
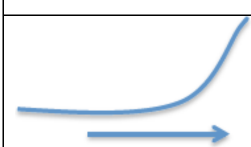
Heterogeneity and basis risk: the evolution of the policyholders mortality is usually different from that of the national population (selection ects). Longevity patterns and longevity improvements are very different for different countries, and different geographic areas.

Factors affecting the mortality: socio-economic level (occupation, income, education, wealth...), gender, marital status, living environment (pollution, nutritional standards, hygiene...). This heterogeneity is very important for longevity risk transfer based on national indices: for too important basis risk, the hedge would be too imperfect. We should take a look at the difference between the national mortality data and an insured portfolio. Insurance companies have much more detailed information:

– Exact ages at death are known and not only the year of death (time continuous data)
– Causes of death are specified
– Characteristics of the policyholders: socio economic level, living conditions...

We can use different distribution in modelling longevity risk (Table 4). We can represent individual longevity risk by a curve with wide variability. We can represent systematic longevity risk by a curve with much less variability. An additional cost for society can be described by distribution with a long tail. Therefore, the response to this notion of longevity risk involves using more robust mortality improvement assumptions and more robust stress-testing scenarios in any analysis of long-term system costs. The rising curve indicates the individual's sense that adverse consequences of aging will grow over time.

Table 4. Distribution used in modelling longevity risk

Representation	Description	Symptoms
	**Individual Longevity Risk:** Variability in an individual's lifespan	Outliving one's retirement assets
	**Aggregated Longevity Risk**: Uncertainty in mortality improvement	Uncertainty in a pension plan's benefit payments due to mortality; inability to manage all risks in a pension system
	**Additional Cost to a Society or a Pension System when Mortality Improvements are Underestimated**	Underreporting of pension and retiree health liabilities; much higher financial burden than expected in a country's social insurance program
	**Adverse Consequences of Living a Long Time**	Heath risks, inadequate retirement savings, risk of elderly abuse, loss of companionship, long-term care needs, and other problems associated with a long life

Source: based on Liaw Huang, Terry T. 2013.

Longevity forecasts can be made using various methods. Forecasting models can be broadly categorized into methods that attempt to understand and use the underlying drivers of mortality and extrapolative methods, which use only historical trends to forecast future developments. In the next section we try to discus model risk.

4. MODEL RISK IN FORECASTING LONGEVITY TRENDS

The last twenty years have seen a growing range of models for forecasting mortality. Early work on stochastic models by Lee and Carter (1992) has been followed by: developments on the statistical foundations and the development of new stochastic models. All well-known models have nice features but also disadvantages. More specifically, the model fits historical data very well, is applicable to a full age range, captures the cohort effect, has a non-trivial (but not too complex) correlation structure, has no robustness problems and can take into account parameter risk, while the structure of the model remains relatively simple.

4.1 Stochastic mortality models

The Lee-Carter model

We can notice as $T_x(t)$ a continuous random variable (non less than zero), which describes lifespan of a person who is *x* years at time *t*. Density function for that random variable we notice as $\mu_x(t)$. The value $\mu_x(t)dx$ is a probability of death in time [*x*, *x* +*dx*] these people, who are *x* years at time *t*. The function $\mu_x(t)$ is called the force of mortality.

This model describes the central mortality rate $m_t(x)$ or the force of mortality, $\mu_x(t)$ at age *x* and time *t* by three series of parameters: $\alpha_x, \beta_{x,}\kappa_t$ as follows:

$$\ln \mu_x(t) = \alpha_x + \beta_x \kappa_t + \varepsilon_{x,t}, \quad \varepsilon_{x,t} \sim N(0,\sigma). \tag{1}$$

α_x gives the average level of mortality at each age over time; the time varying component κ_t is the general speed of mortality improvement over time and β_x is an age-specific component that characterizes the sensitivity to κ_t at different ages; the β_x also describes (on a logarithmic scale) the deviance of the mortality from the mean behavior, κ_t. The error term $\varepsilon_{x,t}$ captures the remaining variations.

To enforce the uniqueness of the parameters, some constraints are imposed on those parameters:

$$\sum \beta_x = 1 \text{ and } \sum \kappa_x = 0 . \tag{2}$$

To calibrate the various parameters we can use standard likelihood methods and thus assume the Poisson distribution for the numbers of deaths at each age and over time.

The P-Spline model

The P-spline model is widely used especially to model the UK mortality rates. The model fits $m_t(x)$ the mortality rates using penalized splines (P-splines), in order to derive future mortality pattern. This approach is used by Currie et al. (2004) to smooth the mortality rates, which can be exploited to derive scenario using stress tests. Generally, the P-spline model takes the form:

$$\log m_t(x) = \sum_{i,j} \theta^{i,j} B_t^{i,j}(x) \tag{3}$$

where $B_{i;\,j}$ are the basis cubic functions used to fit the historical curve, and $\theta^{i,\,j}$ are the parameters to be estimated. The P-spline approach is being different from a basic cubic spline approach when introducing penalties on parameters $\theta^{i,j}$ to adjust the log- likelihood function. Since, to predict mortality, the parameters $\theta^{i,j}$ are to extrapolate using the given penalty.

Model CDB

The CDB model Cairns, Dowd and Blake (Dowd, K., Cairns, A.J.G., Blake, D. at., 2010) introduce a general form of models t hat could be stated depending on the purpose of the modelling but also on the underlying shape of mortality structure. The general model is given by:

$$\text{logit}\, q_t(x) = \kappa_t^1 \beta_x^1 \gamma_{t-x}^1 + ...\kappa_t^n \beta_x^n \gamma_{t-x}^n \tag{4}$$

In this model we have three types of parameters starting with those specific to age β^i and calendar year κ^i and finally the cohort effect parameters γ^i. We should note that the Lee-Carter model is a particular case of this model. The authors also investigate the right criterion to decide upon a particular model (i.e. the parameters to keep or to remove). So, they underline the need for a tractable and a data consistent model and bring out statistical gauges to rank models and determine the better suited to forecast mortality.

A particular example of a model derived from the general form is the model below featuring both the cohort effect and the age-period effect:

$$\text{logit}\,\mu_t(x) = \kappa_t^1 + \kappa_t^2(x-\bar{x}) + \kappa_t^3((x-\bar{x})^3 - \sigma_x^2) + \gamma_{t-x}^n \quad (5)$$

where $\bar{x}$ is the mean age of the historical mortality rates to be fitted (x_0 to x_n), σ^2 is the standard deviation of ages, the parameters κ_t^1 κ_t^2 κ_t^3 correspond respectively to the general mortality improvement over time, the specific improvement for every age (taking into account the fact that mortality for high ages improves slower than for younger) and the age- period related coefficient, $((x - \bar{x})^2 - \hat{\sigma}_x^2)$ corresponds to the age-effect component. Similarly, γ^i represents the cohort-effect component.

4.2. Criteria for stochastic mortality models

These stochastic models vary significantly according to the number of key elements: the number of sources of randomness driving mortality improvements at different ages; assumptions of smoothness in the age and period dimensions; inclusion or not of cohort effects; estimation method. It is important to consider whether a specific stochastic mortality model is a good model or not. Therefore, Cairns et al. (2008) defined criteria against which a model can be assessed:

– Mortality rates should be positive.

– The model should be consistent with historical data.

– Long-term dynamics under the model should be biologically reasonable.

– Parameter estimates and model forecasts should be robust according to the period of data and range of ages employed.

– Forecast levels of uncertainty and central trajectories should be plausible and consistent with historical trends and variability in mortality data.

– The model should be straightforward to implement using analytical methods or fast numerical algorithms.

– The model should be relatively parsimonious.

– It should be possible to use the model to generate sample paths and calculate prediction intervals.

– The structure of the model should make it possible to incorporate parameter uncertainty in simulations.

– At least for some countries, the model should incorporate a stochastic cohort effect.

– The model should have a non-trivial correlation structure.

At the same time Cairns et al. (2008) noted several disadvantages of the Lee-Carter model:

– It is a one-factor model, resulting in mortality improvements at all ages being perfectly correlated (trivial correlation structure).

– For countries where a cohort effect was observed in the past, the model gives a poor fit to historical data.

– The uncertainty in future death rates is proportional to the average improvement rate β_x. For high ages this can lead to the uncertainty being too low, since historical improvement rates have often been lower at high ages.

– The basic version of the model can result in a lack of smoothness in the estimated age effect β_x.

4.3. Multifactor stochastic mortality model

Besides biological reasonableness, we also consider the issue of the plausibility of forecast levels of uncertainty in projections at different ages. The objective is to judge whether or not the pattern of uncertainty at different ages is consistent with historical levels of variability at different ages: we can sometimes conclude that a particular model is less plausible on the basis of forecast levels of uncertainty. An important additional issue concerns the robustness of forecasts relative to the choice of the sample period and age range.

Where a model is found to lack robustness with one sample population, there is a danger that it will lack robustness if applied to another sample population, and therefore it should either be used with great care or not used at all.

Multifactor models have appeared in recent years. For instance, Renshaw and Haberman (2003) proposed the model

$$\log m(t, x) = \beta_x^1 + \beta_x^2 \kappa_t^2 + \beta_x^3 \kappa_t^3 \tag{6}$$

where κ_t^2 and κ_t^3 are dependent period effects (e.g. a bivariate random walk). Renshaw and Haberman (2006) proposed one of the first stochastic models for population mortality to incorporate a cohort effect. Renshaw and Haberman's generalization of the Lee-Carter model

$$\log m(t, x) = \beta_x^1 + \beta_x^2 \kappa_t^2 + \beta_x^3 \gamma_{t-x}^3 \tag{7}$$

where κ_t^2 is a random period effect and γ_{t-x}^3 is a random cohort effect that is a function of the (approximate) year of birth, $(t-x)$.

We analyse next some of mortality models investigated by Cairns et al. (2011). As in previous models: the functions β_x^i, κ_t^i and γ_{t-x}^i are age, period and cohort effects, respectively, $\bar{x}$ is the mean age over the range of ages being used in the analysis, $\hat{\sigma}_x^2$ is the mean value of $(x - \bar{x})^2$, n_a is the number of ages, and $c = t - x$.

M1 $$\log m(t, x) = \beta_x^1 + \beta_x^2 \kappa_t^2 \tag{8}$$

M2 $$\log m(t, x) = \beta_x^1 + \beta_x^2 \kappa_t^2 + \beta_x^3 \gamma_{t-x}^3 \tag{9}$$

M3 $$\log m(t, x) = \beta_x^1 + n_a^{-1} \kappa_t^2 + n_a^{-1} \gamma_{t-x}^3 \quad (10$$

M4 $$\operatorname{logit} q(t, x) = \kappa_t^1 + \kappa_t^2 (x - \bar{x}) \tag{11}$$

M5 $$\operatorname{logit} q(t, x) = \kappa_t^1 + \kappa_t^2 (x - \bar{x})^2 + \kappa_t^3 ((x - \bar{x})^2 - \hat{\sigma}_x^2) + \gamma_{t-x}^4 \tag{12}$$

M6 $$\operatorname{logit} q(t, x) = \kappa_t^1 + \kappa_t^2 (x - \bar{x}) + \gamma_{t-x}^3 (x_c - \bar{x}) \tag{13}$$

Looking for some properties of listed models we can notice that M2, M3, M5 and M6 include a cohort effect. M2 is the Renshaw and Haberman (2006) extension of the original Lee-Carter model (M1). M3 is a special case of M2, and M5 and M6 are extensions of the original CBD model (M4). The original Lee–Carter and CBD models had no cohort effect, and provide useful benchmarks for comparison with the four models involving cohort effects.

Additionally we can notice that:

a) κ_t^1 (which can be interpreted as the `level' of mortality) has a downward trend, reflecting generally improving mortality rates over time.

b) κ_t^2 (the `slope' coefficient) has a gradual upward drift, reflecting the fact that, historically, mortality at high ages has improved at a slower rate than at younger ages.

c) κ_t^3 (the `curvature' coefficient) is more erratic,

d) γ_{t-x}^i, fluctuates around zero with no systematic trend or curvature.

The models mentioned above have some good features:

– the α_x term of the Lee-Carter model makes it suitable for full age ranges,

– the Renshaw-Haberman model addresses the cohort effect and fits well to historical data,

– the Currie model (P-spline) has a simpler structure than the Renshaw-Haberman model, making it more robust,

– the models of Cairns have multiple factors, resulting in a non-trivial correlation structure, while the structure of the model is relatively simple.

5. CONCLUSION

Longevity risk appears to be a very complex risk, due to its specificities compared with other insurance risks – in particular the trend sensitivity, the geographical variability and the associated long-term maturities – and its potential correlations with other sources of risk, financial and non-financial. All these models can be applied for original data. For different population we have data which we can apply. In the previous research we tried to estimate some models for chosen aspects of longevity risk. We discussed individual longevity risk for Poland and the Central Europe (Trzpiot G., Majewska J. 2015 a, b, c). Robust approach to life expectancy projection was used for the UK data (Trzpiot G., Majewska J. 2015d). It is a big advantage to analyse at macro-level the impacts of longevity on the whole economy and the environment. Understanding and quantifying errors is important for a number of stakeholders with interests in: population mortality forecasts; forecasts of sub-population mortality, calibration of multi-population mortality models; assessment of levels of uncertainty in mortality forecasts; the calculation of life insurer liabilities and economic capital; annuity pricing; pension plan buyout pricing; the assessment of basis risk in longevity hedges; and the effectiveness of hedges and hedging instruments – is still a big advantage.

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GLOBALNE STARZENIE SIĘ – NATURA RYZYKA DŁUGOWIECZNOŚCI

Streszczenie. W artykule przedstawiamy badania nad problemem modelowania ryzyka długowieczności ryzyka. Omawiamy pojęcie ryzyka długowieczności, aby lepiej zrozumieć wszystkie powiązane wyzwania w sferze zarządzania ryzykiem z punktu widzenia finansowego i ubezpieczeniowego. Artykuł prezentuje również opinię na temat praktycznych zadań związanych z rosnącą długości życia. Jednocześnie, wzrost długości życia zwiększył potrzebę rozwoju rynków kapitałowych, celem zarządzania i transferu ryzyka. Dlatego, również podkreślamy przyszłe zarządzanie ryzykiem długowieczności z finansowego punktu widzenia.

Słowa kluczowe: ryzyko długowieczności, transfer ryzyka, stochastyczne modelowanie śmiertelności, dynamika populacji.

JEL: J11, C18, C22, G19.