Longevity risk factors: the perspectives of selected European countries

Justyna Majewska[1], Grażyna Trzpiot [2]

Abstract

A significant and ongoing debate about the economic, financial and social implications of longevity was initiated a few years ago. . Both individuals and governments are increasingly concerned about the effects of aging, however, their concerns differ. Individuals are more concerned about increased longevity, because it affects their own financial and labor market plan, whereas governments are more concerned about old-age dependency as an aspect of population aging. In this paper, in the first part set of economic, financial and demographic variables are discussed in a context of their impact on longevity. In the second part, using principal component analysis, we identify risk factors of longevity by means of macroeconomic and financial data collected from the last decade for selected countries from Europe.

Keywords: *longevity, risk, PCA*
JEL Classification: *C130, C180*

1. Introduction

The changing and ageing structure of European population is driven primarily by two factors. Firstly, improvements in life expectancy mean that people are living longer and reaching older ages. Along with this factor, there is a decrease in fertility, people are having fewer children and are having children later than ever. The observed improvements in longevity and changing structure of the population bring both opportunities and challenges for the economy, services, and society at national and local levels (ONS UK, 2018).

Institutions and individuals have to face some specific challenges related with longevity risk, i.e. the risk that actual survival rates and life expectancy will exceed expectation or pricing assumptions, resulting in greater-than-anticipated retirement cash flow needs (NAIC, 2019). For individuals longevity risk is the risk of outliving one's assets resulting in a lower standard of living, reduced care or just return to employment. For those institutions providing covered individuals with guaranteed retirement income, this is the risk of underestimating survival rates resulting in increased liabilities to cover promised payments.

For a few years discussions and research have been intensively carried out on how to deal with the economic and financial implications of longevity– in both academic circles and the business press (e.g., Olshansky et al., 2009; Bloom et al., 2010; Cocco and Gomes, 2011; IFM, 2012). It is a problem of shrinking populations, reduced economic growth, negative effect on

[1] Corresponding author: University of Economics in Katowice / Department of Demography and Economic Statistics, 50 1 Maja St., 40-287 Katowice, justyna.majewska@ue.katowice.pl.

[2] University of Economics in Katowice / Department of Demography and Economic Statistics, 50 1 Maja St., 40-287 Katowice, grazyna.trzpiot@ue.katowice.pl.

pension and health care system. Understanding the nature of longevity risk is crucial to model and manage this risk.

The goal of this paper is to examine a set of reasonable macroeconomic and financial variables for determining factors of longevity risk. As a research method we use principal component analysis. Sources of longevity risk are discussed on the example of three European countries with significant differences in level of economic growth, life expectancy, pensions and welfare systems.

2. Economic and financial implications of longevity

The impact of aging on the economy and financial markets has been analysed widely in the literature. There are different implications for individuals, for households, for insurers, for local and central governments. Concerns about the economic impacts of aging fall into three main areas: potential worker shortages, excessive expenditure on health services and old-age care and shortfalls in pension funding. The impact of aging on financial stability occurs largely through changes in investment demand, financial market asset prices and returns, and liabilities among individuals and institutions.

An aging population means that there will be fewer working-age people in the economy. It leads to a supply shortage of qualified workers, making it more difficult for businesses to fill in-demand roles. An economy that cannot fill in-demand occupations faces adverse consequences, e.g., declining productivity, higher labor costs, delayed business expansion and reduced international competitiveness. In some instances, a supply shortage may push up wages, thereby causing wage inflation and creating a vicious cycle of price or wage spiral. Given that demand for health care rises with age, countries with aging populations must allocate more money and resources to their health care systems. With health care spending as a share of GDP already high in most advanced economies, it is difficult to increase spending while ensuring care improvements and other social needs not to deteriorate in the case of publicly funded or government-administered health care systems. Countries with large elderly populations depend on smaller pools of workers in which to collect taxes to pay for higher health costs, pension benefits and other publicly funded programs. The combination of lower tax revenue and higher spending commitments on health care, pension and other benefits is a major concern for advanced industrialized nations.

Empirical studies uncovered evidence that population aging has an important impact on financial markets because of its expected impact on saving rates and the demand for investment funds (e.g. Poterba, 2001; Poterba , 2004). The rising demand for safe assets by the elderly may lead to safe asset shortages and an overpricing of safe assets. These effects may be counterbalanced by defined-benefit funds with funding gaps in the current low interest-rate environment, which may invest in risky assets to enhance expected returns. Population age structure can affect stock market prices and the real returns of different classes of financial assets. Relations between long-term government bond yields and demographics are well documented (see Andrews and Bonnar, 2018).

3. Selected variables associated with longevity risk

Empirical investigation of relations between longevity phenomenon and selected macroeconomic and financial variables is made for selected European countries with different level of economic growth and life expectancy, i.e. for Germany, Spain and Poland. From longevity perspective, life expectancy (at birth and at aged 65, for both sexes) in Poland is shorter than in Germany and Spain, while life expectancy is the highest in Spain. Spain is expected to become the world's second oldest country by 2050, behind Japan. According to HDI index[3] Germany – since 2010 – has been in the group of five the most developed countries, Spain – in the second ten, and Poland – in the third ten the most developed countries in the world (UNDP, 2018).

The selection of variables was preceded by an analysis of literature in the field of research on determinants of macroeconomic and financial implications of ageing. The analysis broadly focuses on the issues: economic welfare, current standard of living, current possible increase of welfare resulting from labour market, population longevity, and financial markets and investments opportunities.

In the process of identification of risk factors the following variables are taken into consideration:

1. Demographic old-age dependency ratio[4] – traditionally seen as an indication of the level of support available to older persons (those aged 65 or over, i.e. age when they are generally economically inactive) by the working age population (those aged between 15 and 64; expressed per 100 persons of working age (15–64)).
2. Life expectancy at birth[5] – the mean number of years that a new-born child can expect to live if subjected throughout his life to the current mortality conditions (age specific probabilities of dying; expressed in years).
3. Life expectancy at age 65[6] – the mean number of years still to be lived by a man or a woman who has reached the age 65, if subjected throughout the rest of his or her life to the current mortality conditions (age-specific probabilities of dying; expressed in years).
4. Consumer Price Index (CPI)[7] – the change over time in the prices of consumer goods and services acquired, used or paid for by households (measured in an index, 2015 base year).

[3] The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of these three dimensions (http://hdr.undp.org/en/, access: 12.12.2018).

[4] In 2016 this ratio (per 100 person of working age 15–64) amounted to 32.4 (Germany), 28.7 (Spain), 24.2 (Poland). Projected ratio for 2050: 51.2 (Germany), 62.1 (Spain), 54.6 (Poland).

[5] In 2016 LE at birth (male and female): 81.0 (Germany), 83.5 (Spain), 78.0 (Poland).

[6] In 2016 LE at aged 65 (male and female): 19.8 (Germany), 21.6 (Spain), 18.5 (Poland).

[7] In 2016 CPI annual growth rate %: 0.48 (Germany), -0.20 (Spain), -0.58 (Poland). In general, CPI decreased over the last 7 years. CPI projected for 2020: 2.16 (Germany), 1.74 (Spain), 2.95 (Poland).

5. Real GDP per capita[8] – the ratio of real GDP to the average population of a specific year; a measure of economic activity used as a proxy for the development in a country's material living standards (a limited measure of economic welfare; per capita, in current prices).
6. Unemployment rate[9] – represents unemployed persons as a percentage of the labour force (the total number of people employed and unemployed) [% of active population].
7. Real effective exchange rates (REER)[10] – aims to assess a country's price or cost competitiveness relative to its principal competitors in international markets; changes in cost and price competitiveness depend not only on exchange rate movements but also on cost and price trends (indices).
8. Gross saving[11] – measures the portion of gross national disposable income that is not used for final consumption expenditure; gross national saving is the sum of the gross savings of the various institutional sectors (current prices).
9. Long-term government bond yields[12] – refer to central government bond yields on the secondary market, gross of tax, with residual maturity of around 10 years; the bond or the bonds of the basket have to be replaced regularly to avoid any maturity drift (%).
10. Long-term care (health) expenditures[13] – expenditures on a range of medical and personal care services that are consumed with the primary goal of alleviating pain and suffering and reducing or managing the deterioration in health status in patients with a degree of long-term dependency (share of current expenditures on health).
11. Currency exchange rates[14]: EUR/USD, EUR/PLN.
12. Stock market a main index[15]: DAX in Germany, IBEX35 in Spain, WIG20 in Poland.
13. Real Estate Funds and Equity/Dividend Funds: Unilmmo Deutchland and Allianz Vermögensbildung Deutschland (Germany), Seguffondo Inversion and Bankia Dividendo España FI (Spain), PZU UFK Investor Nieruchomości i Budownictwa and Investor FIO Subfundusz Akcji Spółek Dywidendowych (Poland).

Economic and demographic variables are derived from the Eurostat database (variables 1–9) and the OECD database (variable 10), stock quotes – from stock exchange (Frankfurt, Madrid, Warsaw) and other financial database (the Yahoo Finance) (variables 12 and 13). Time series were obtained for the time period 2010–2016. As the sample is short, some data were converted to monthly frequency (and then all variables were expressed as indices using a base

[8] In 2016 GDP (milions USD): 4.1M (Germany), 1.7M (Spain), 1.1M (Poland). Projected for 2030: 4.3M (Germany), 1.9M (Spain), 1.4M (Poland).

[9] In 2016 unemployment rate (% of labour force): 4.1 (Germany), 19.6 (Spain), 6.2 (Poland).

[10] In 2016 REER index (2010=100): 100.88 (Germany), 99.2 (Spain), 89.79 (Poland).

[11] In 2016 gross saving (2010=100): 116.97 (Germany), 101.64 (Spain), 113.85 (Poland).

[12] In 2016 long-term gov. bond yields (2010=100): 3.28 (Germany), 32.78 (Spain), 52.51 (Poland).

[13] In 2016 long-term health care exp. (2010=100): 113.69 (Germany), 97.18 (Spain), 95.62 (Poland).

[14] Rate of return 2010–2016: EUR/USD –26.34% , EUR/PLN +7.63%.

[15] Rate of return 2010–2016: WIG20 –18.45%; DAX +92.72%; IBEX35 -21.85%.

year of 2010), with maintaining the strength and direction of correlation between variables. The period does not cover years from the financial crisis of 2008–2009 to avoid unusual observations from financial market.

Relations between the above-mentioned variables and longevity are analysed in empirical studies. Some relations are clear, while others are still a subject of debate (in particular, the impact of longevity on inflation is unclear). Due to the complexity of these relations and their multidimensionality, a few confirmed consequences of longevity are worth mentioning (e.g. Bloom et al., 2010; Mandel et al., 2017; Rachel and Smith, 2015; Maestas at al., 2016; Acemoglu and Restrepo, 2017): reducing investment return, reducing public saving, reducing growth rates, reducing real interest rates, affecting labour supply and returns, reallocation of saving from riskier to safe assets may lead to potential mispricing of risk, running down assets may result in negative wealth effects.

Based on the results of Majewska and Trzpiot (2016), the above mentioned variables could be grouped into five clusters: standard of living risk, elderly needs risk, financial risk, longevity risk and long-term investment risk. However, it should be taken into account that the time period in their research covered years of financial crisis 2008–2009.

4. Principal component analysis of variables associated with longevity risk

The rotated Principal Component Analysis, an adaptive data analysis technique, was used to specify risk factors of longevity. Relations between some of considered variables suggest the existence of new variables – the principal components – that are the linear combinations of the original demographic, macroeconomic and financial variables. All calculations were made in R software environment.

As a result of PCA three components for each country separately were selected and treated as F_i risk factors. Risk factor loads are presented in Tables 1–3. Factors were simplified by orthogonal (varimax), which minimised the number of variables with high loadings on each factor (orthogonal rotation to transform the extracted factors into uncorrelated, independent factors to increase the interpretability of the factors). The correlations between the factors were explained by factor loadings, values greater than or equal to 0.4 were used to indicate significant correlations between the component and the variables. The components with eigenvalues (sum of the squared factor loadings) greater than or equal to 1 were retained for analysis (components with variances less than one produce negligible information than one of the original variables and, hence, are not worth retains).

For Germany (Table 1) the first principal component explains 59% of the variation, while all components – 83%. The first component is identified as the wealth risk because of the high positive factor loadings on GDP, gross savings, long-term care expenditures combined with a high negative weighting on long-term government bond yields and unemployment rate. All these variables are associated with standard of living risk and elderly needs risk. The second component was high loadings of variables that reflect longevity. Advancing age due to increased

life expectancy itself is a risk factor. The last component explains 10% of total variance and was loaded only by REER and real estate fund and it would associate with financial market risk.

Table 1. Risk factor loads of principal components: Germany

Variable	*F*1	*F*2	*F*3
Old Age Dependence Ratio	0.93		
GDP	0.92		
Gross Saving	0.93		
CPI	0.80		
Long-term Care Expenditures	0.95		
Long-term Government Bond Yields	–0.89		
REER			0.92
Unemployment Rate	–0.90		
Dividend Fund	0.75		
Real Estate Fund			0.63
LE65		0.88	
LE birth		0.97	
DAX	0.75		
EUR/PLN	0.74		
EUR/USD	–0.85		
Cumulative Var	*0.59*	*0.73*	*0.83*

Table 2. Risk factor loads of principal components: Spain

Variable	*F*1	*F*2	*F*3
Old Age Dependence Ratio	0.93		
GDP		–0.94	
Gross Saving		–0.55	
CPI	0.83		
Long-term Care Expenditures		–0.66	
Long-term Government Bond Yields	–0.78		
REER	–0.61		
Unemployment Rate		0.93	
Dividend Fund	0.69		
Real Estate Fund	–0.91		

Variable	*F*1	*F*2	*F*3
LE65	0.85		
LE birth	0.94		
IBEX35			0.96
EUR/PLN			–0.65
EUR/USD	–	–	–
Cumulative Var	*0.44*	*0.68*	*0.82*

For Spain (Table 2) the first component was the highest loadings with variables that reflect elderly needs and longevity. Thus, this component was identified as long-term standard of living. It can be supported by noting that the factor loadings associated with long-term care expenditures, REER and real estate fund are negative. The second component proved to be a strong indicator of longevity risk related with GDP, gross savings, unemployment rate and long-tern expenditures. This component was clustered with standard of living and long-term investments risk factors. The last component explains 14% of total variance and has been positively loaded with IBEX35 returns and negatively – with EUR to PLN exchange rate. It would be associated with financial market risk.

Table 3. Risk factor loads of principal components: Poland

Variable	*F*1	*F*2	*F*3
Old Age Dependence Ratio	0.86		
GDP	0.89		
Gross Saving	0.77		
CPI	0.72		
Long-term Care Expenditures	–0.84		
Long-term Government Bond Yields	–0.91		
REER		0.80	
Unemployment Rate	–	–	–
Dividend Fund		0.92	
Real Estate Fund			–0.97
LE65	0.95		
LE birth	0.95		
WIG20		0.88	
EUR/PLN		–0.81	
EUR/USD	–	–	–
Cumulative Var	*0.54*	*0.77*	*0.87*

For Poland (Table 3) the first component was loaded with variables related with increasing life expectancy as well as economic well-being and explains 54% of total variance. Therefore, the component was identified as demo-economic risk. The second component was heavily loaded with dividend fund, WIG20 returns, REER and negatively with EUR to PLN exchange rate. It would be identified as financial market risk and explained 23% of total variance. The last component was loaded negatively only by a real estate fund and would be associated with individual wealth risk.

Conclusions

The current study focused on determining significant longevity risk factors through principal component analysis for three different European countries. The study performed PCA to reduce 14 inter-correlated demographic, economic and financial variables into groups of independent factors. For each country, within considered variables, 3 principal components with high explained variance (82%, 83% and 87% respectively for Spain, Germany and Poland) are sufficient to capture the nature of longevity risk.

The complex nature of longevity risk do not allow for constructing factors consisting of the same variables for each country. It is due to the fact that longevity increases at different rates across different countries. Therefore, impact of population aging differs across countries. This difference is linked to the state of health, age-structure profiles, lifestyle, progress in disease diagnosis and medical treatment, to mention a few. This is the reason why we need to have a real understanding of the causal factors underlying longevity, the ageing process, and the characteristics governing different populations. In our opinion, the risk factors will vary depending on the country selected for next the study.

Interestingly, some factors constitute a mix of demographic, financial and economic variables. It enables explanation of key differences between considered countries; however, some trends are noticeable. Countries are prepared for the challenges of population aging in varying degrees. Clustering of variables informs about diversification in both opportunities and challenges for the economy, services and society at national and local levels.

There is a need for further analysis made for various time periods, especially asset returns are sensitive to the start and end dates of the period covered by the analysis. Moreover, comparative analyses between countries with share similar demographic histories would be very important due to the growing popularity of coherent (multi-population) mortality (longevity) models, where a single population is modeled in reference to another coherent population. Little work has been done on the importance or selection of the reference group and there is no standard procedure on how to select populations for the reference population.

References

Acemoglu, D., & Restrepo, P. (2017). Secular Stagnation? The Effect of Aging on Economic Growth in the Age of Automation. *American Economic Review,* 107(5), 174–179.

Andrews, D., & Bonnar, S. (February, 2018). Population Aging, Implications for Asset Values, and Impact for Pension Plans: An International Study. Retrieved December 01, 2018, from https://www.cia-ica.ca/docs/default-source/2018/218014e.pdf.

Bloom, D.E., Canning, D., & Fink, G. (2010). Implications of population ageing for economic growth. *Oxford Review of Economic Policy,* 26(4), 583–612.

Bosworth, B., Bryant, R., & Burtless, G. (2004). The Impact of Aging on Financial Markets and the Economy: A Survey (July 1st, 2004). *The Brookings Institution*. Available at SSRN: https://ssrn.com/abstract=1147668.

Cocco, J.F., & Gomes, F. (2011). Longevity Risk, Retirement Savings and Financial Innovation (March 1st, 2011). *Netspar Discussion Paper 3*. Available at SSRN: https://ssrn.com/abstract=1888305

IFM The Financial Impact of Longevity Risk – 2012. (2012). Retrieved from https://www.aarp.org/livable-communities/learn/demographics/info-12–2012/financial-impact-of-longevity.html

Longevity risk. (2019). Retrieved January 2nd , 2019, from https://www.naic.org/cipr_topics/topic_longevity_risk.htm

Maestas, N., Mullen, K., & Powell, D. (2016). The Effect of Population Aging on Economic Growth, the Labor Force and Productivity. *Working Papers.* Rand Corporations.

Office for National Statistics UK. Living longer: How our population is changing and why it matters. (2018). Retrieved January 2, 2019, from https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/ageing/articles/livinglongerhowourpopulationischangingandwhyitmatters/2018-08-13

Olshansky, S.J., Carnes, B.A., & Mandell, M.S. (2009). Future trends in human longevity: Implications for investments, pensions and the global economy. *Pensions: An International Journal,* 14(3), 149–163.

Poterba, J.M. (2004). Impact of Population Aging on Financial Markets in Developed Countries. Paper presented to the Symposium on Global Demographic Change, Federal Reserve Bank of Kansas.

Poterba, J.M. (2001). Demographic Structure and Asset Returns, *Review of Economics and Statistics*, 83, 565–584.

Rachel, L., & Smith, T. (2015). Secular Drivers of the Global Real Interest Rate. *Bank of England Staff Working Paper 571*. J.P. Morgan Asset Management Multi-Asset Solutions.

Trzpiot, G., & Majewska, J. (2016). The Impact of Longevity on Long-term Investments Returns: Scenarios for Europe. Available at https://www.cass.city.ac.uk/__data/assets/pdf_file/0020/334082/L12-32-TRZPIOT-and-MAJEWSKA.pdf

UNDP (2018). Human Development Indices and Indicators 2018: Statistical update, UN, New York.