LIFE EXPECTANCY AND INCOME INEQUALITY IN NORTH MACEDONIA: AN EMPIRICAL ANALYSIS

Marijana Cvetanoska
Faculty of Economics-Skopje,
Ss. Cyril and Methodius University in Skopje, North Macedonia
marijana.cvetanoska@eccf.ukim.edu.mk

Biljana Tashevska
Faculty of Economics-Skopje,
Ss. Cyril and Methodius University in Skopje, North Macedonia
biljana.tashevska@eccf.ukim.edu.mk

Predrag Trpeski
Faculty of Economics-Skopje,
Ss. Cyril and Methodius University in Skopje, North Macedonia
predrag.trpeski@eccf.ukim.edu.mk

EXTENDED ABSTRACT

Purpose The aim of this study is to examine the relationship between income inequality, measured by the Gini coefficient, and life expectancy in North Macedonia, applying the Autoregressive Distributed Lag (ARDL) bounds testing approach, using annual data from 2000 to 2022. The analysis includes GDP per capita, education (primary school enrolment), health expenditures, and hospital beds as control variables, all of which affect life expectancy by shaping living standards, knowledge and behaviors, access to health care, and the efficiency of medical services. Income inequality and health outcomes are central aspects of economic and social development. High income inequality has been linked to disparities in health and life expectancy through differences in healthcare access, education, and social cohesion (Wilkinson and Pickett, 2009; Deaton, 2024). The Global Risks Report 2023 highlights that global crises, such as the COVID-19 pandemic and geopolitical tensions, exacerbate economic inequalities, further affecting healthcare access and social outcomes (World Economic Forum, 2023). At the macro level, maintaining and improving population health is recognized as a key policy for sustainable development (Bayati *et al.*, 2013). Life expectancy at birth is a widely used measure of population health and longevity, and, although health is multi-dimensional, it is commonly adopted as a proxy for overall population health (Rabbi Fazle, 2013; Sharma, 2018). This study presents empirical findings that are rarely discussed in existing research and offers valuable guidance for policies aimed at enhancing health outcomes and reducing inequality, which in turn can strengthen human capital and promote sustainable development in North Macedonia.

Methodology This study investigates the impact of socio-economic factors on life expectancy in North Macedonia using time-series data. To analyze both short-run and long-run dynamics, the Autoregressive Distributed Lag (ARDL) Bounds modeling approach was employed. The ARDL Bounds approach is a technique for examining linear cointegration, developed by Pesaran (1997), Pesaran and Smith (1998), and Pesaran *et al.* (2001). This method offers several advantages over other cointegration techniques, including the ability to estimate both short-run and long-run parameters within a single model, addressing endogeneity issues, and testing for cointegration among variables with different orders of integration, such as I(0) and I(1). Moreover, it is well-suited for small sample sizes (Jebli and Belloumi, 2017) and provides unbiased long-run estimates (Odhiambo, 2008).

10.47063/EBTSF.2025.0027
http://hdl.handle.net/20.500.12188/34507

The analysis is based on annual data for North Macedonia covering the period 2000–2022. All variables are obtained from the World Development Indicators of the World Bank database. Specifically, the Gini index is used as a measure of income inequality, while life expectancy at birth (in years) is employed as the dependent variable. Additional control variables include GDP per capita (constant 2015 US$), primary school enrolment (% of gross), health expenditures (% of GDP), and hospital beds (per 1,000 people). The selection of variables that determine life expectancy is guided by insights from previous research as well as our preliminary estimations. GDP per capita is included as a control variable to account for the general level of economic development, as previous research (Neumayer and Plümper, 2016) indicates that higher income levels are associated with longer life expectancy. Primary school enrolment is incorporated as a control variable to reflect the influence of education on life expectancy, since education enhances health awareness, income, and overall social well-being, all of which contribute to improved health outcomes and increased longevity (Kabir, 2008). Two health supply indicators (health expenditure and the number of hospital beds) are included, given the well-established connection between health care factors and health outcomes (Blazquez-Fernández *et al.*, 2017).

The empirical analysis followed a structured approach to ensure the reliability and validity of the results. Initially, all variables were tested for unit roots to determine their order of integration, ensuring that none were integrated of order two (I(2)), which is a prerequisite for applying the ARDL approach. The Lee-Strazicich LM unit root test was employed to account for potential structural breaks, as conventional tests may produce biased results when such breaks are present, consistent with Perron's (1989) findings on the importance of considering structural changes in time series analysis. Subsequently, several diagnostic tests were conducted to validate the assumptions of the regression model: normality of residuals, serial correlation, heteroskedasticity and the stability of the estimated model. To explore long-run relationships among the variables, the ARDL Bounds Test for cointegration was applied, allowing the identification of a stable equilibrium even with a small sample by comparing the calculated F-statistic to critical bounds for I(0) and I(1) variables. The ARDL model was then reparametrized into an Error Correction Model (ECM) form to distinguish short-run dynamics from long-run equilibrium relationships, with the ECM term capturing the speed of adjustment following deviations from equilibrium. Finally, a robustness check was performed using the Fully Modified Ordinary Least Squares (FMOLS) method, which corrects for potential endogeneity and serial correlation, providing reliable long-run coefficient estimates.

Findings First of all, the Lee-Strazicich LM unit root test was employed, and the results are summarized as follows. The test for the *Gini index* indicates the presence of a structural break in 2017. The minimum test statistic is statistically significant (-2.36>-3.49*[1]), suggesting that the series becomes stationary after first difference. For *life expectancy*, structural breaks were identified in 2018/2019. The findings reveal that the series does not follow a classical unit root process but rather attains stationarity in levels with a structural break (-3.35>-3.49*). In the case of *GDP per capita*, breaks were detected in 2006 and 2017. The test results indicate that the series is stationary in the presence of structural breaks. Given the trending nature of GDP per capita, the Lee-Strazicich test with breaks is considered a more robust approach in this context (-2.30>-4.91*). The *education variable* showed a structural break around 2016/2017. The evidence suggests that the variable is stationary in levels (-3.09>-3.49*). For the *health expenditure* indicator, structural breaks were identified in 2011 and 2019. The test results indicate that the series is stationary in levels (-2.62>-3.49*). Finally, for the *number of hospital*

[1] * critical value 5%

beds, a structural break was observed in 2018, and the series is confirmed to be stationary in levels (I(0)) (-1.59>-3.49*).

Diagnostic tests showed that the model is free from autocorrelation and heteroscedasticity, the errors are normally distributed, the functional form is properly specified, and the coefficients of the model remain stable. Robustness check using FMOLS showed that GDP per capita positively affects life expectancy, while the Gini index has a marginal negative effect, and education and healthcare expenditures behave as expected. High R^2 and adjusted R^2 values (0.86 and 0.81, respectively) confirm that the model explains a substantial portion of the variation in the dependent variable and demonstrate the robustness of the results.

The ARDL Bounds Test confirms the presence of a significant long-run cointegrating relationship, indicating that the variables share a stable equilibrium over time. Given that the F-statistic is well above the I(1) bounds, the null hypothesis of no long-run relationship can be rejected. According to the results (Table 1), the effect of LIFE_EXP lag value (-1), DGINI and its lag value (-1), GDP_PC and its lag value (-1), HEALTH and its lag value (-1), and BEDS and its lag value (-1) on LIFE_EXP is statistically significant in the short run.

Table 1. Short-run and long-run coefficients

Short-term coefficients and ERC model				
Variable	Coefficient	Standard error	t-statistics	Probability
LIFE_EXP(-1)	-0.299745*	0.097982	-3.059197	0.0156
DGINI	-0.130299*	0.016521	-7.886896	0.0000
DGINI(-1)	-0.173871*	0.017003	-10.225650	0.0000
GDP_PC	0.004271*	0.000274	15.567030	0.0000
GDP_PC(-1)	-0.004152*	0.000267	-15.573520	0.0000
EDU	0.000648	0.012487	0.051909	0.9599
HEALTH	0.790743*	0.075658	10.451530	0.0000
HEALTH(-1)	-0.468239*	0.074928	-6.249180	0.0002
BEDS	-8.226424*	0.663593	-12.396790	0.0000
BEDS(-1)	1.613360*	0.458582	3.518150	0.0079
COINTEQ(-1)	-1.299745 *	0.037341	-34.807730	0.0000
Long-term term coefficients				
Variable	Coefficient	Standard error	t-statistics	Probability
DGINI	-0.234023*	0.019209	-12,18317	0.0000
GDP_PC	0.000091	0.000158	0.574961	0.5811
EDU	0.000499	0.009601	0.051943	0.9598
HEALTH	0.248128*	0.042362	5.857385	0.0004
BEDS	-5.087968*	0.706798	-7.198616	0.0001
C	94.493740	3.986370	23.704210	0.0000

** Indicates stationarity at the 1% and 5% significance levels, respectively*
(Source: Authors' calculations in EViews)

Increases in health expenditures and GDP per capita positively influence life expectancy, whereas increases in income inequality and the number of hospital beds are associated with reductions in life expectancy. Education does not exert a statistically significant effect on life expectancy within the model. One possible explanation is that improvements in education typically generate long-term benefits rather than immediate outcomes.

In the long run, the effect of DGINI, HEALTH, and BEDS on LIFE_EXP is statistically significant, indicating that changes in these variables have a lasting impact on life expectancy over time. The long-run estimation results reveal that income inequality has a strong negative and highly significant impact on life expectancy, confirming that greater inequality reduces longevity. Health expenditure is positively and significantly associated with life expectancy, emphasizing the importance of investments in healthcare. Conversely, GDP per capita and education show positive but statistically insignificant effects, suggesting that their influence may be indirect or delayed. Interestingly, the number of hospital beds has a significant negative effect, which may reflect inefficiencies in healthcare delivery or the fact that higher bed availability often corresponds to poorer underlying health conditions rather than improved outcomes. Overall, inequality reduction and effective healthcare spending emerge as the key long-term drivers of life expectancy.

The ECM coefficient (COINTEQ=-1.29) indicates rapid adjustment toward the long-run equilibrium following short-term shocks, reflecting that after a short-term shock, life expectancy at birth adjusts rapidly toward the long run but may temporarily oscillate around the equilibrium. This highlights the system's strong tendency to return to equilibrium after short-term fluctuations.

Originality/value The findings highlight key determinants of life expectancy in North Macedonia, showing that while short-term changes in inequality, GDP per capita, health spending, and healthcare infrastructure affect outcomes, the system self-corrects toward long-run equilibrium. Income inequality and health expenditure are the most influential factors that improve life expectancy at birth, whereas GDP per capita, education, and hospital beds capacity have limited long-term effects, emphasizing the need for policies targeting inequality reduction and efficient healthcare investment. Based on existing studies, while some research has examined life expectancy trends and regional factors in North Macedonia or its healthcare system development (Miladinov, 2020; Saliu et al., 2022; Milevska Kostova et al., 2024), there is a clear lack of comprehensive analyses investigating the combined short-term and long-term effects of socio-economic determinants, such as income inequality, GDP per capita, education, and health expenditures. This gap highlights the novelty of the present study, which systematically explores these factors using an ARDL approach to uncover both short-run and long-run influences on life expectancy.

Keywords: *ARDL bounds testing approach, Income inequality, Life expectancy, North Macedonia*

JEL classification: *C32, I14, I15, O52*

REFERENCES

Bayati, M., Akbarian, R. and Kavosi, Z. (2013), "Determinants of life expectancy in Eastern Mediterranean Region: A health production function", *International Journal of Health Policy and Management*, Vol. 1, pp. 1-7.

Blazquez-Fernández, C., Cantarero-Prieto, D. and Pascual-Saez, M. (2017), "Health expenditure and socio-economic determinants of life expectancy in the OECD Asia/Pacific area countries", *Applied Economics Letters*, Vol. 24 No. 3, pp. 167-169.

Deaton, A. (2024), *The Great Escape: Health, Wealth, and the Origins of Inequality*, Princeton University Press, Princeton, NJ, USA.

Jebli, M.B. and Belloumi, M. (2017), "Investigation of the causal relationships between combustible renewables and waste consumption and CO_2 emissions in the case of Tunisian maritime and rail transport", *Renewable and Sustainable Energy Reviews*, Vol. 71, pp. 820-829.
Kabir, M. (2008), "Determinants of life expectancy in developing countries", *The Journal of Developing Areas*, Vol. 41 No. 2, pp. 185-204.
Miladinov, G. (2020), "Socioeconomic development and life expectancy relationship: Evidence from the EU accession candidate countries", *Genus*, Vol. 76 No. 2, pp. 1-20.
Milevska Kostova, N., Atanasova, S., Dimkovski, V., Stevanovski, G., Stæhr Johansen, A., Winkelmann, J. and Rechel, B. (2024), "North Macedonia: Health system review", *Health Systems in Transition*, Vol. 26 No. 6, pp. 1-164.
Neumayer, E. and Plümper, T. (2016), "Inequalities of income and inequalities of longevity: A cross-country study", *American Journal of Public Health*, Vol. 106 No. 1, pp. 160-165.
Odhiambo, N.M. (2008), "Financial depth, savings and economic growth in Kenya: A dynamic causal linkage", *Economic Modelling*, Vol. 25 No. 4, pp. 704-713.
Perron, P. (1989), "The great crash, the oil price shock, and the unit root hypothesis", *Econometrica*, Vol. 57 No. 6, pp. 1361-1401.
Pesaran, M.H. (1997), "The role of economic theory in modelling the long run", *The Economic Journal*, Vol. 107 No. 440, pp. 178-191.
Pesaran, M.H., Shin, Y. and Smith, R.J. (2001), "Bounds testing approaches to the analysis of level relationships", *Journal of Applied Econometrics*, Vol. 16 No. 3, pp. 289-326.
Pesaran, M.H. and Smith, R.P. (1998), "Structural analysis of cointegrating VARs", *Journal of Economic Surveys*, Vol. 12 No. 5, pp. 471-505.
Rabbi Fazle, A.M. (2013), "Imbalance in life table: Effect of infant mortality on lower life expectancy at birth", *Journal of Scientific Research*, Vol. 5 No. 3, pp. 479-488.
Saliu, H.R., Rusi, M. and Sadiki, S. (2022), "Lifestyle as a factor in longevity in the Pollog region", *Innovative Systems Design and Engineering*, Vol. 12 No. 6, pp. 52-57.
Sharma, R. (2018), "Health and economic growth: Evidence from dynamic panel data of 143 years", *PLOS ONE*, Vol. 13 No. 10, e0204940.
Wilkinson, R.G. and Pickett, K. (2009), *The Spirit Level: Why More Equal Societies Almost Always do Better*, Allen Lane, London, UK.
World Economic Forum (2023), *The Global Risks Report 2023*, World Economic Forum.

10.47063/EBTSF.2025.0027
http://hdl.handle.net/20.500.12188/34507