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RESEARCH ARTICLE

Does health expenditure matter for life expectancy in Mediterranean countries?

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Abstract
This research assesses the effect of health expenditure and sanitation on life expectancy in Mediterranean countries. We also consider other drivers of life expectancy, such as CO_2 emissions and economic growth. The study covers the period 2000–2018, and the recently developed method of moments quantile regression (MMQR) approach was utilised to assess these interconnections. This method is immune to outliers and creates an asymmetric interrelationship between variables. The outcomes from the MMQR unveiled that economic growth, health expenditure, and sanitation enhanced life expectancy in all quantiles (0.1–0.90). Furthermore, in all quantiles (0.1–0.90), the effect of CO_2 emissions on life expectancy was negative. Moreover, as a robustness check, the FMOLS, DOLS, and FE-OLS long-run estimators were applied, and the outcomes validated the MMQR outcomes. Based on the results generated, policymakers in these nations should implement effective environmental and public health measures that will pay off in the long run through improved health as a result of lower emissions of CO_2, as well as increased economic expansion and productivity.

Keywords Life expectancy · Health expenditure · Sanitation · Environmental sustainability · Method of moment quantile regression

Introduction

The average outstanding years of life at a certain age of an individual, which reflects the typical patterns of death for distinct age groups, is referred to as life expectancy. Longer life expectancy (LE) is desired for its intrinsic worth and for the essential achievements in life of each person (Sen 1998). It is one of the most significant components of the Human Development Index, and increasing life expectancy has been a major focus of several medical studies. Excellent longevity and health are linked to increased productivity, as a necessary stimulant for sustainable economic expansion (Raffin and Seegmuller 2014; Bekun et al. 2019). A key factor in life expectancy is income level, with numerous scholars determining that a nation's income level correlates with its life expectancy level (Bloom and Canning 2007). Nevertheless, even among nations with a similar per capita income, considerable differences in life expectancy exist.

Understanding the factors that influence life expectancy is difficult, as people's health and lifespan are influenced by numerous nutritional, socioeconomic, genetic, lifestyle, and ecological variables. Mackenbach and Looman (2015), for instance, linked rising national wealth to reduced mortality from communicable diseases in European nations between 1990 and 2008, when they investigated the upward transition of the Preston curve (the association between real income and life expectancy) for a group of European nations. Increased European LE has been aided by this decrease in mortality. Moreover, Jaba et al. (2014) and Ranabhat et al. (2014) established that healthcare spending can have a considerably favourable influence on LE. Similarly, in research conducted on forty nations in sub-Saharan Africa (SSA), Arthur and Oaikhenan (2017) found that enhanced LE is attributable to increasing healthcare spending. However, studies by Rahman et al. (2018) and Van del Heuvel

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and Olaroiu (2017) found no significant interconnection between healthcare spending and LE in thirty-one European nations and the South Asian Association for Regional Cooperation (SAARC) region, respectively. An investigation by Filmer and Pritchett (1997) also found no significant interconnection.

Sanitation is also linked to LE, as poor sanitation leads to the spread of life-shortening illnesses, including cholera, diarrhoea, hepatitis A, and typhoid, among others. According to data, inadequate sanitation is responsible for roughly 432,000 lives per year (Alhassan et al. 2021). Conversely, polluted or dirty drinking water spreads various illnesses that reduce LE through neonatal mortality (Islam et al. 2018). According to a WHO report (2020), there are 485,000 diarrhoeal deaths each year, most of which are caused by contaminated drinking water. LE statistics were utilised by Islam et al. (2018) to evaluate the health quality of life and status in poor and lower-middle income nations. Among other things, they discovered that economic liberty, fraud, CO_2 emissions, and achievement in meeting millennium development goals are all strongly linked to longer LE.

The most important driver of LE in recent research has been identified as environmental deterioration. According to the WHO (2020), air contamination claimed 4.2 million premature deaths worldwide in 2016, and this number is expected to rise further since nine out of ten people endure poor air quality. Ecological deterioration may harm people's health in several ways. For example, extreme exposure to air pollution is linked to an increase in chronic illnesses (such as heart disease, lung cancer, and asthma) and early death (Apergis et al. 2020). Ecological deterioration also makes waterborne illnesses like dengue fever and malaria more likely (Tanser et al. 2003). Moreover, research has found that environmental destruction promotes ecosystem unpredictability, increasing the likelihood of droughts and floods (He et al. 2021), potentially leading to detrimental changes in water quality and food production. This in turn contributes to increased mortality, especially amongst infants and the aging, as well as vulnerable individuals from lower socioeconomic backgrounds.

According to Wang et al. (2014) and Bekun et al. (2021), air quality has a significant influence on the longevity of the aged, who are less adaptive to environmental deterioration due to various illnesses. Likewise, Majeed and Ozturk (2020) found that nations with higher levels of ecological deterioration have higher newborn mortality rates, and vice versa. Notwithstanding the factual data shown above, several nations continue to reject the implementation of key environmental measures. In pursuing stronger economic growth, emerging nations place greater strain on natural resources (such as land, forests, and water), and their increased output encourages higher CO_2 emissions (Akadiri et al. 2021; Adebayo et al. 2021; Bekun 2022 Kirikkaleli et al. 2021).

In this regard, Oladipupo et al. (2021) found that environmentally degraded nations fail to recognise the long-term benefits of robust environmental laws on economic health and growth, and their lack of environmental awareness necessitates additional consideration. To the best of our knowledge, no research has yet considered the factors that influence LE in Mediterranean nations, particularly the negative impact of environmental damage on LE. It is therefore hoped that this study will add new knowledge to the literature. The study employs LE as a public health outcome, with the goal of examining the major drivers of LE in Mediterranean nations. The research's main hypothesis is that the positive interrelationship between economic expansion and LE will remain present and that environmental deterioration will have a far greater negative influence on LE than is commonly assumed in empirical investigations.

This study contributes to the literature in three ways, taking into consideration the preceding arguments and issues. First, to our knowledge, this is the first study to use the method of moments quantile regression (MMQR) approach to examine the impact of health spending, economic growth, sanitation, and CO_2 emissions on LE in Mediterranean countries. Second, this study contributes to the steadily growing body of work using the MMQR. The adoption of this method with fixed effects allows for a more intuitive understanding of the heterogeneity interrelationship. Furthermore, unlike classic mean regressions, this method enables heterogeneity interconnectedness at various levels of conditional quantiles distribution (0.1–0.90 quantiles). Third, the study incorporates economic growth, CO_2 emissions, and sanitation into the healthcare–life expectancy nexus for the case of Mediterranean nations. The evaluation of this nexus at various quantiles is motivated by several reasons. Firstly, conditional-mean evaluations are compared. Because of the more robust conditional quantiles, these analyses can distort the impact of outliers emerging from LE drivers. Another reason is that quantile regression is more appealing in the context of panel regression analysis because of its extra intuitive usage. Finally, our discoveries will be vital in implementing successful public health and environmental measures, particularly as these nations' older populations grow. The research findings will aid the implementation of targeted health treatments for the community's most vulnerable groups; the development of an environmental degradation surveillance system; and the strengthening of environmental regulations and laws.

The next section presents a summary of prior studies, followed by data and methodology in the "Theoretical framework, data, and methodology" section. The findings and discussion are presented in the "Findings and discussion" section, and the "Conclusion and policy directions" section presents the conclusion and policy suggestions.

Literature review

Studies on the impact of economic growth, CO_2 emissions, sanitation, and health expenditure on LE have produced mixed findings depending on the methodologies applied, timeframe, and country or countries being investigated.

While public investment and expenditure per capita on health services is a key factor in managing the health of a society, less developed countries or regions must provide for other necessities besides health expenditure. These factors include accessing clean water, improving infrastructure and roads, providing literacy and education services, and coping with malnutrition and poor sanitation, among others (Gilligan and Skrepnek 2015). Studies on assessing long and healthy life spans in eastern Mediterranean countries have concluded that factors such as economic development and stability, a lower unemployment rate, and higher productivity are critical (Bayati et al. 2013). Although national health systems can be compared and judged based on the population average LE, heterogeneous socioeconomic indicators can produce a disparity between LE and longevity (Obrizan and Wehby 2018). Moreover, implementing a policy for greater expenditure without a concomitant cost effectiveness analysis does not guarantee longevity or higher LE (Blazquez-Fernández et al. 2017). For this reason, cost-effectiveness analyses are essential since they help achieve the efficient allocation of resources. However, the analysis of the cost of inputs or resources relative to the output benefit can differ from one country to another, with diverse socio-economic and health outcomes. Certain unexpected events, such as the emergence of COVID-19, also create the conditions for greater global health expenditure. Since 2020, a larger percentage of gross domestic product (GDP) has proportionately been invested in the public health sector. While richer countries can spend more on public health care and thus provide better services, poorer countries with low total incomes must cope with budget deficits and debt financing, and so achieving longevity is difficult.

Several studies have discussed the causal relationship between CO_2 emissions and economic growth (Holtz-Eakin and Selden 1995; Magazzino 2016; Chaabouni and Saidi 2017). Higher CO_2 emissions or environmental pollution takes a heavier toll on the health of a society and individuals, with greater follow-on expenditure for the health sector. Underlying the estimation of LE is mortality prevalence. Air pollution and non-optimum temperature have an inverse relationship with LE but a positive relationship with the mortality rate (Ai et al. 2021). Bilgili et al. (2021) studied the link between public and private healthcare expenditure, economic growth, and environmental pollution for thirty-six Asian countries. The quantile regression results for the panel data indicated that spending on both public and private health can reduce CO_2 emissions. The study found that higher spending on healthcare services in Asian countries is a foundation for better environmental quality.

Examining the environmental pollution effects on the mortality of children and adults, Feng et al. (2019) considered the tuberculosis rate, survival rate, and health expenditure efficiencies using data for twenty-eight European Union (EU) countries and fifty-three others. Energy efficiency was more significantly acquired in those countries not in the EU, and health expenditure efficiencies were also lower in these countries. To date, several studies have statistically examined the link between energy consumption, economic growth, and environmental degradation. The main outcome was that economic activities spur energy exploitation and environmental degradation, whereas environmental and energy conservation are harmless to the growth of the economy (Ang 2007; Liu and Hao 2018; Gorus and Aydin 2019; Raza et al. 2019; Ozcan et al. 2020). The empirical relationship between types of energy consumption, economic growth, and carbon emissions in economies was examined by Liu and Hao (2018). Their study employed a panel dataset of sixty-nine countries over 43 years. The analysis of panel Granger causality deduced long-term bidirectional causalities for CO_2 emissions, energy consumption, industry value-added, and GDP per capita.

Additionally, Cai et al. (2018) investigated the empirical relationship between clean energy consumption, economic growth, and CO_2 emissions in G7 countries. The empirical analyses indicated an association between health risks, economic activities, and energy consumption. Environmental pollution can cause a higher rate of societal mortality, which highlights the health risk perspective. Furthermore, quantified air quality co-benefits of climate policy across sectors and regions were disintegrated. The study suggests a joint policy for different public sectors such as agriculture, manufacturing, energy, climate, and air quality. The design of an optimum climate policy facilitates the reduction of CO_2 emissions and thus lessens mortality (Vandyck et al. 2020). Likewise, Rasoulinezhad et al. (2020) employed the generalised method of moments (GMM) for Commonwealth of Independent States (CIS) members over three decades. The findings signify that variability in mortality could be ascribed to CO_2 emission variability.

Enormous fossil fuel use increases the possibility of mortality from cardiovascular disease (CVD), diabetes mellitus (DM), cancer, and chronic respiratory disease (CRD). Recently, Koengkan et al. (2021) evaluated the impact of renewable energy consumption on reduced outdoor air pollution and deaths, using a panel dataset for nineteen Latin American and Caribbean countries covering 1990–2016 and the econometric technique of quantile regression. The findings revealed a significant and positive impact of economic growth and fossil fuel consumption on CO_2 emissions. Generally, the effect of fossil fuel consumption on the mortality rate was significant. In a similar study, Rahman et al. (2020) examined and reported the causes of the LE in the most polluted countries. The Granger causality test suggested a bidirectional relationship between sanitation and LE, and unidirectional causality was observed for CO_2 emissions.

Several studies have focused on LE at birth. Jafrin et al. (2021) emphasised that sanitation significantly impacts LE at birth in Bangladesh, India, Pakistan, Nepal, and Sri Lanka. In addition to examining impact factors on LE at birth, Ranabhat et al. (2018) included healthy LE as a dependent variable to measure the number of years a healthy person can live or stay alive. The study used a dataset for 193 members of the United Nations (UN), and the explanatory variables of sanitation, vaccination, and health coverage for all residents were the most significant determinants of longevity. It was found that assured health services for all residents can inversely affect both inequality of LE at birth and healthy LE. In other words, health coverage enables society to prevent mortality when financial assistance is available. Moreover, several studies (see Khan et al. 2021; Adebayo 2022; An et al. 2021; Agyekum et al. 2022; Razzaq et al. 2020, 2021; Zhang et al. 2021; Riti et al. 2022; Akadiri et al. 2022; Aziz et al. 2021a, b, 2020; Irfan et al. 2022) also found a significant association between economic growth, life expectancy, and CO_2 emissions.

Theoretical framework, data, and methodology

Theoretical framework

Considering that health is viewed as a long-lasting capital stock that generates an output of healthy time, Grossman (1972) suggested a framework for health production. In general, the function of health production is a valuable instrument for determining a country's health condition. There are certain outputs and inputs in the production function of health. For example, the output of the health production function is morbidity, whereas the inputs comprise the environment, health care, income, health and medical costs, and genetic variables (Jakovljevic et al. 2016). As a result, life expenditure is the most commonly utilised variable in describing health output and is a comprehensive indicator of a country's health condition (Jakovljevic et al. 2016; Kim and Lane 2013). On this basis, we analysed the influence of sanitation, economic growth, health spending, and CO_2 emissions (see Fig. 1) using techniques and processes from the literature (Grossman 1972; Halicioglu 2011). The current analysis examines the following health paradigm:

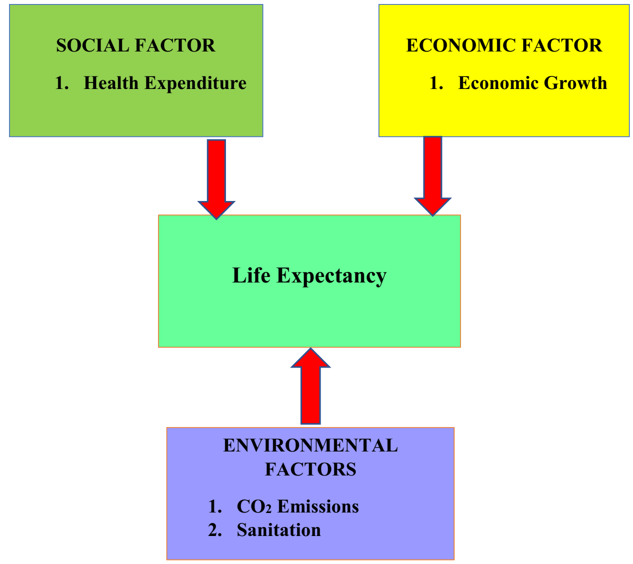

Fig. 1 Theoretical framework

$$LE_{it} = f\left(HE_{it}, GDP_{it}, SAN_{it}.CO_{2it}\right) \quad (1)$$

where *LE*, *HE*, *GDP*, *SAN*, and CO_2 stand for life expectancy, health expenditure, economic growth, sanitation, and CO_2 emissions.

Data

The study used data from 2000 to 2018 for ten Mediterranean countries. The dependent variable is life expectancy (LE), and the independent variables are health expenditure (HE), CO_2 emissions (CO_2), economic growth (GDP), and sanitation (SAN). The variables are measured as follows: LE is LE at birth in total (years); economic growth is GDP per capita; CO_2 emissions are CO_2 metric tonnes per capita; health expenditure is current health expenditure (% of GDP); and sanitation is people using at least basic sanitation services (% of population). The dataset for all the variables was gathered from the World Bank database, with the exception of CO_2, which was gathered from British Petroleum's database.

Methodology

The five-step methodology employed in this study is as follows: (1) We examined the slope heterogeneity and

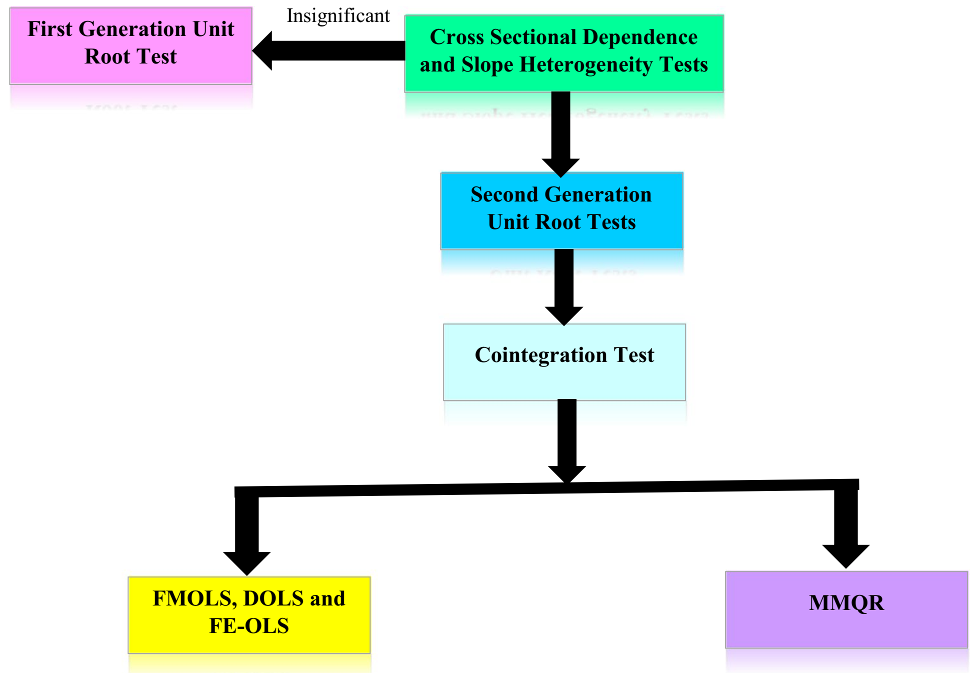

Fig. 2 Flow of analysis

cross-sectional dependency (CSD) problems; (2) the unit root characteristic of the indicators was tested; (3) the cointegration connection was examined; (4) the long-run interrelationship was assessed; and (5) We examined the causal relationship between variables. Figure 2 presents the flow of the analysis.

Slope homogeneity and cross-sectional dependence tests

Inorder to inspect cross-sectional dependency (CSD), we utilised the Lagrange multiplier (LM) and CSD and tests were applied. The formulae are presented in Eqs. 2 and 3, respectively (Pesaran 2004; Breusch and Pagan 1980). Globalisation supports the interconnectedness of countries in all three political, social, and economic domains. The skewed outcomes of the panel data can be observed as a result of this interconnectedness. Therefore, this phenomenon emphasises the importance of CSD assessment.

$$LM = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{2} \tag{2}$$

$$CD = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{2}\right) \tag{3}$$

where$N$ denotes sample size, T signifies time-period, and the estimated correlation of the residuals between nation i and nation j is symbolised by $\hat{\rho}_{ij}^{2}$. The conundrum of CSD as one of the elements of slope heterogeneity (SH) may be due to incorrect estimation. Thus, in the second phase, we employed the SH test proposed by Pesaran and Yamagata (2008) to assess the slope coefficient homogeneity. The $\hat{\Delta}$ statistic test was employed to determine the heterogeneity or homogeneity of the slope coefficients as disclosed as follows:

$$\hat{\Delta} = \sqrt{N}\left(\frac{N^{-1}\widehat{S-k}}{\sqrt{2k}}\right) \tag{4}$$

Note that, when the sample size is small, $\hat{\Delta}_{adj}$ can be expressed as shown in Eq. 5.

$$\hat{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\widehat{S-k}}{\sqrt{var\left(\hat{Z}_{iT}\right)}}\right) \tag{5}$$

Panel unit root

In the third phase, the indicators' unit root characteristics were tested. Spurious regression are presents when indicators are stable at the first difference I(1). This necessitates determining whether the variables are stationary to address the issue of CSD across nations. Therefore, the current paper utilises the second generation unit root tests such as CADF and CIPS tests initiated by (Pesaran 2007) to capture the stationarity attributes of the variables. The CADF statistic was computed using Eq. 6.

$$\Delta Y_{i,t} = \gamma_i + \gamma_i Y_{i,t-1} + \gamma_i \overline{X}_{t-1} + \sum_{l=0}^{p} \gamma_{il} \Delta \overline{Y_{t-l}} + \sum_{l=1}^{p} \gamma_{il} \Delta Y_{i,t-l} + \epsilon_{it} \quad (6)$$

In Eq. 6, $\overline{Y}_{t-1}$ and $\Delta\overline{Y_{t-l}}$ correspond to the cross-section average. To compute individual CADF, the CIPS statistic as formulated in Eq. 7 was used (Pesaran 2007).

$$\widehat{\mathrm{CIPS}} = \frac{1}{\mathrm{N}} \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{CADF_i} \quad (7)$$

Generally, the stationarity of the indicators is tested by an alternative hypothesis, but non-stationarity is suggested by the null hypothesis for the CADF and CIPS tests.

Cointegration test

Prior to the prediction of the long-run associations, the cointegration connection needs to be examined. Thus, the Westerlund cointegration test was applied (Westerlund 2007). The cointegration tests proposed by previous scholars (Kao et al. 1999; Johansen and Juselius 1990; Pedroni 2004) overlook cross-section correlation, and so to cope with this issue, we employed Westerlund's suggested formula (2007), as represented in Eqs. 8–11.

$$G_t = \frac{1}{N} \sum_{i-1}^{N} \frac{\acute{a}_i}{SE(\acute{a}_i)} \quad (8)$$

$$G_\alpha = \frac{1}{N} \sum_{i-1}^{N} \frac{T\acute{a}_i}{\acute{a}_i(1)} \quad (9)$$

$$P_T = \frac{\acute{a}}{SE(\acute{a})} \quad (10)$$

$$P_\alpha = T\acute{a} \quad (11)$$

Method of moments quantile regression

The present research utilized dynamic ordinary least square (D-OLS) initiated by Kao et al. (1999) and fixed effect ordinary least square (FE-OLS) approaches to make a comparison. The FE-OLS approach is an upgrade over Driscoll and Kraay standard errors initiated by (Driscoll and Kraay 1998). Moreover, this statistical method is robust with heterogeneity, cross-sectional dependence, and autocorrelation. The panel framework of dynamic cointegration, mean difference within variations, and cross-sections are modified to cointegrate equilibrium to address the heterogeneity issue. As stated by Pedroni (2004), the FM-OLS is capable of resolving these problems. Panel settings for D-OLS are being extended using Monte Carlo simulations (Kao et al. 1999). Even with the small sample size, it is clear that it is impartial when contrasted to other estimators. D-OLS can manage endogeneity by employing lagged and lead differences.

Koenker and Bassett (1978) proposed a panel quantile regression model at first. This regression is used to assess dependent variance and conditional mean in relation to explanatory parameter values. Even when the data contains outliers, quantile regression produces more reliable findings. As a result, we used the (Machado and Silva 2019) MMQR method. This statistical approach was developed to assess the distributional and heterogeneous impacts of multiple quantiles (Sharif et al. 2021; Anwar et al. 2021; Aziz et al. 2021c). The location-scale variant conditional quantile estimates Qy(τ|X) is illustrated as follows.

$$Y_{it} = \alpha_i + X'_{it}\,\beta + \left(\delta_i + Z'_{it}\Upsilon\right)U_{it} \quad (12)$$

The parameters and the probability P $\{\delta_I + Z'_{it}\Upsilon > 0\} = 1$. $(\alpha, \beta', \delta, \Upsilon')$ are to be estimated. Moreover, i denotes discrete, and fixed effects are illustrated by (αi, δi), $i = 1, \ldots, n$, and k-vector of known parts of X is illustrated by Z which are differentiable transformations with element l recognized by

$$Z_l = Z_l(X), l = 1, \ldots, k \quad (13)$$

X_{it} is separately and proportionately distributed for across fixed *I and* time *t*. Likewise, U_{it} is distributed fixed cross-sections and across time, and it is orthogonal to X_{it} (Machado and Silva 2019), The remainder of the components, on the other hand, do not provide strict exogenous behaviour. This is illustrated as follows:

$$Q_y(\tau|X_{it}) = (\alpha_i + \delta_i q(\tau)) + X'_{it}\beta + Z'_{it}\Upsilon q(\tau) \quad (14)$$

The vectors of the regressors are denoted by X_{it} in Eq. 14 . The independent variable quantile distribution is depicted by Y_{it} (for example, carbon emissions) is denoted by $Q_y(\tau|X_{it})$, which is illustrated as conditional on the independent variable location and $X*_{it}$. $-\alpha i\,(\tau) \equiv \alpha i + \delta_i\, q(\tau)$ is the scaler coefficient which shows the quantile fixed effect τ for an individual *i*. Unlike other least-square fixed effects, the individual effect does not have an intercept shift. Since the variables are time-invariant, heterogonous influences are subject to change and conditional distribution across quantiles. $q(\tau)$ Illustrates the $\tau -$ th sample quantiles that are calculated by determining the resulting optimization problem.

$$min\,_q \Sigma_i \Sigma_t \rho_\tau \left(R_{it} - \left(\delta_i + Z'_{it}\Upsilon\right)q\right) \quad (15)$$

Table 1 Slope homogeneity outcomes

Test	Value	*p* value
$\hat{\Delta}$	23.040*	0.000
$\hat{\hat{\Delta}}_{\text{adjusted}}$	27.854*	0.000

* $p < 1\%$

Due to the obvious evidence of CSD and SH, this investigation is limited to checking the stationarity of variables using the second-generation CIPS unit root test (Table 2). Table 3 shows that all the indicators are integrated in the same order, which leads us to apply the Westerlund (2007) co-integration approach. In addition, Table 3 shows the CSD test findings. The cross-sections are dependent, as evidenced by the significant test statistics. A typical unit root test might produce deceptive findings as a result of these issues, and so we employed a unique method for determining the variables' stationarity. As a result, it is possible to conclude that the sample nations (Egypt, Portugal, Cyprus, Malta, Israel, France, Turkey, Italy, Greece, and Spain) are interrelated and highly dependent on one another. Any global or local economic shock in one nation would have ramifications in the others.

Table 2 CSD and CIPS and CADF unit root test

Variables	CSD Results		CIPS		CADF	
	Pesaran scaled LM	Pesaran CD	*I(0)*	*I(1)*	*I(0)*	*I(1)*
CO_2	54.028*	3.3616*	−2.059	−4.863*	−1.923	−4.502*
GDP	32.306*	10.149*	−2.183	−4.965*	−2.852	−4.746*
HE	25.118*	7.4383*	−1.479	−4.635*	−2.132	−4.867*
LE	81.748*	28.643*	−2.436	−3.838*	−2.720	−3.838*
SAN	74.692*	2.8563*	−1.934	−3.557*	−1.746	−3.084**

*, **, and *** stands for $p < 1\%$, $p < 5\%$, and $p < 10\%$

Table 3 Westerlund (2007) test results

	Gt	Ga	Pt	Pa
Sample value	−2.893	−6.583	−7.632	−7.310
p values	0.038**	0.841	0.056***	0.794

*$p < 1\%$, **$p < 5\%$ and ***$p < 10\%$, respectively

Table 4 MMQR Outcomes

	Lower quantile			Middle quantile			Higher quantile		
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
HE	0.0252*	0.0306*	0.0319*	0.0350*	0.0383*	0.0410*	0.0439*	0.0462*	0.0497**
GDP	0.1676*	0.1620*	0.1605*	0.1573*	0.1538*	0.1509*	0.1479*	0.1424*	0.1348*
SAN	0.1674*	0.1872*	0.1978*	0.2012*	0.2115*	0.2233*	0.2308*	0.2517*	0.2640*
CO_2	−0.009*	−0.029*	−0.0491*	−0.0618*	−0.0825*	−0.1161*	−0.1236*	−0.1341*	−0.1494*
C	3.9217*	3.8535*	3.8359*	3.7974*	3.7554*	3.7205*	3.6845*	3.6551*	3.6165*

*$p < 1\%$, **$p < 5\%$, and ***$p < 10\%$, respectively

where $\rho_\tau(A) = (\tau - 1)AI\{A \le 0\} + TAI\{A > 0\}$ indicates the check function.

Findings and discussion

Pre-estimation test outcomes

Prior to evaluating the model described in the preceding section, we looked for slope homogeneity (SH) and cross-sectional dependence (CSD), which are more frequent issues with panel data. The significance value of delta (Δ) and adjusted delta (Δadj) in Table 1 reveal that the model suffers from SH, as seen by the significant values of delta.

Cointegration test outcomes

This research utilised the Westerlund (2007) technique to address the issues of CSD and heterogeneity. The co-integration findings shown in Table 3 reveal that the model has long-run co-integrating connections, as seen by the significant panel and group statistics.

Method of moments quantile regression outcomes

Next, we assessed the influence of health expenditure, economic expansion, sanitation, and CO2 emissions on the LE in these Mediterranean nations using the novel quantile regression suggested by Machado et al. (2019). The uniqueness of this technique is that it can catch the influence of the independent variables on LE in each quantile (0.1–0.90). Table 4 presents the MMQR results. In each quantile (0.1–0.90), the effect of health expenditure on LE is positive, with the effect more pronounced as we move across the lower to higher quantiles. Thus, in each quantile (0.1–0.90), increasing health expenditure enhances LE. Moreover, across all quantiles (0.1–0.90), we observed a positive interconnection between economic expansion and LE. Across all quantiles (0.1–0.90), the influence of economic expansion on LE is positive, with the effect diminishing as we move across the lower to higher quantiles. Thus, in each quantile (0.1–0.90), increased economic expansion improves LE. In addition, in each quantile (0.1–0.90), the effect of sanitation on LE is positive, with a more pronounced effect as we move from the lower to higher quantiles. Thus, in each quantile (0.1–0.90), an increase in sanitation enhances LE. Lastly, as expected, the effect of CO2 emissions on LE is negative and significant across all quantiles (0.1–0.90), and the negative influence increases as we move towards the higher quantiles (0.1–0.90). Therefore, in each quantile (0.1–0.90), CO2 emissions diminish LE. Furthermore, Fig. 3 presents the comparison of the four estimators (DOLS, FMOLS, FE-OLS, and MMQR).

Long-run estimator outcomes

As a robustness check for the MMQR, we applied the FMOLS, DOLS, and FE-OLS long run estimators to capture the association between LE and the regressors (health expenditure, economic expansion, sanitation, and CO2 emissions) which had been established, and we proceeded by assessing the effect of health expenditure, economic expansion, sanitation, and CO2 emissions on LE using long-run estimators (FMOLS, DOLS, and FE-OLS). The outcomes are presented in Table 5. As expected, we observed a

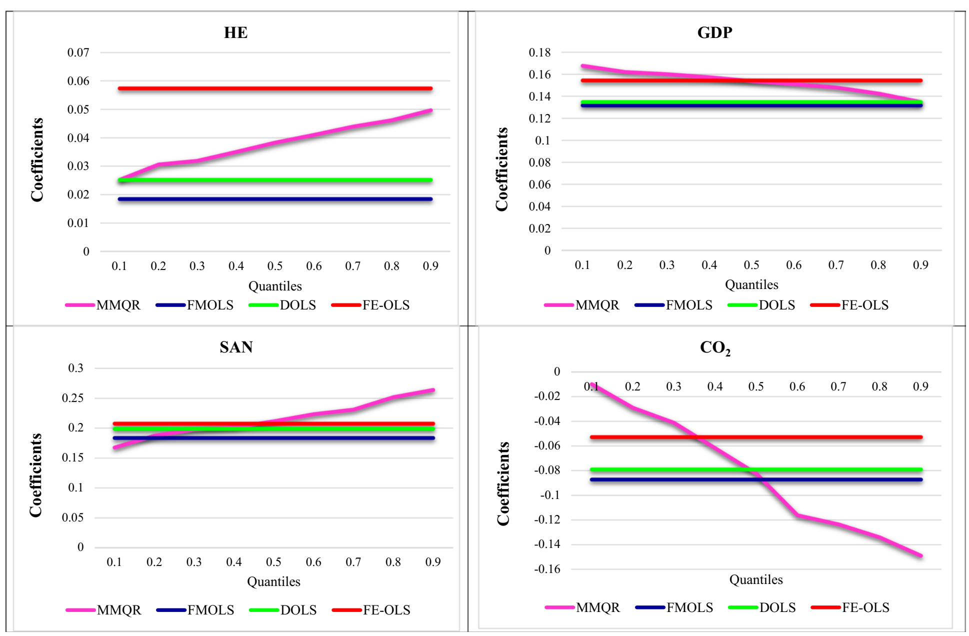

Fig. 3 Comparison of panel estimations (FMOLS, DOLS, FE-OLS, and MMQR)

Table 5 FMOLS, DOLS, FE-OLS Outcomes

	FMOLS			DOLS			FE-OLS		
Variable	Coefficient	*t*-Statistic	Prob	Coefficient	*t*-Statistic	Prob	Coefficient	*t*-Statistic	Prob
HE	0.0184*	3.4841	0.0013	0.0252***	1.9142	0.0572	0.0574*	2.9244	0.0039
GDP	0.1317*	11.646	0.0000	0.1348*	10.664	0.0000	0.1544*	16.292	0.0000
SAN	0.1835*	4.1590	0.0001	0.1987*	4.0739	0.0001	0.2074*	6.2237	0.0000
CO_2	−0.0872*	−11.004	0.0000	−0.0790*	−10.072	0.0000	−0.0528*	−15.387	0.0000
R^2	0.97			0.96			0.97		
Adj R^2	0.96			0.95			0.97		

*$p < 1\%$, **$p < 5\%$, and ***$p < 10\%$, respectively

positive interconnectedness between health expenditure and LE, which infers that a 1% upsurge in health expenditure contributes to a 0.0184%, 0.0252%, and 0.0574% upsurge in LE with other indicators held constant, as disclosed by both FMOLS, DOLS, and FE-OLS long-run estimators, respectively. Thus, increases in health expenditure enhance the LE in these Mediterranean nations. We also noticed that the influence of economic expansion on LE is positive. This demonstrates that a 1% upsurge in economic expansion contributes to a 0.1317%, 0.1748%, and 0.1544% upsurge in LE, keeping other indicators constant, as shown by both FMOLS, DOLS, and FE-OLS long-run estimators, respectively. Therefore, an upsurge in economic expansion improves the LE in these Mediterranean nations. Additionally, the effect of sanitation on LE is positive and significant. This demonstrates that a 1% upsurge in sanitation contributes to a 0.1835%, 0.1987%, and 0.2074% upsurge in LE, holding other factors constant, as shown by FMOLS, DOLS, and FE-OLS long-run estimators, respectively. Therefore, an increase in sanitation improves the LE in these Mediterranean nations.

As anticipated, we observed negative interconnectedness between CO2 emissions and LE. This infers that a 1% upsurge in CO2 emissions contributes to a 0.0872%, 0.0790%, and 0.0528% decrease in LE, keeping other indicators constant, again as disclosed by both FMOLS, DOLS, and FE-OLS long-run estimators, respectively. Thus, an increase in health expenditure enhances the LE in these Mediterranean nations.

Discussion of findings

This section of the empirical analysis presents the discussion of the results. We observed positive interconnectedness between economic expansion and LE, which concurs with theory. As stated by Shahbaz et al. (2019) and Selck and Deckarm (2015), higher economic expansion improves LE by more years. Individuals who live in nations with a high per capita income are likely to enjoy a higher LE and standard of living (Adebayo and Kirikkaleli 2021). Furthermore, we established positive and significant interconnectedness between sanitation and LE. This result is unsurprising because proper sanitation and waste management help to prevent disease by limiting the possibility of microorganisms polluting water sources and thus disease transmission. The studies of Selck and Deckarm (2015), Mújica et al. (2015), and Jafrin et al. (2021) also reported that improvement in sanitation facilities tends to promote LE at birth.

Moreover, we observed that healthcare expenditure has a significant positive impact on LE, implying that higher healthcare expenditure would increase LE. This result is consistent with previous studies of Owumi et al. (2021) on Nigeria, Nkemgha et al. (2021) on Cameroon, and Martín Cervantes et al. (2020) on Europe, which all indicated that increases in healthcare expenditure enhance LE. Contrarily, studies by Igbinedion (2019) on Nigeria and Rahman et al. (2018) on SAARC nations found that improved health care does not enhance LE.

As expected, the effect of CO_2 emissions on LE is negative, suggesting that a rise in CO_2 emissions mitigates the LE in these Mediterranean nations. The study of Murthy et al. (2021) on the link between LE and CO_2 emissions using a dataset from 2000 to 2016 showed that an increase in energy consumption can lead to higher CO_2 emissions and thus reduce LE in 54 countries. This outcome is as expected, since carbon monoxide causes blood clotting, especially when it reacts with haemoglobin, which tends to cut the supply of oxygen in the respiratory system after long exposure. Given the severe implications of these carbon dioxide emissions on the health of a country's citizens, there is an urgent need for relevant organisations to implement tighter controls aimed at minimising such likely effects. Figure 4 presents the summary of the findings.

Conclusion and policy directions

Conclusion

In this research, we assessed the drivers of life expectancy (LE) in Mediterranean nations (Egypt, Portugal, Cyprus, Malta, Israel, France, Turkey, Italy, Greece, and Spain), such

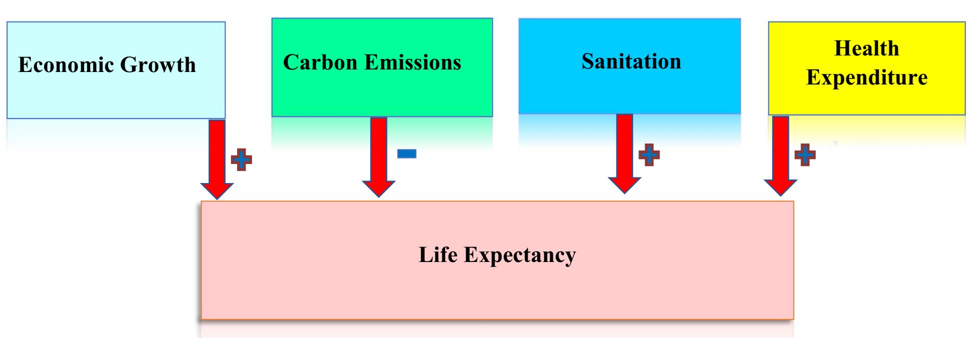

Fig. 4 Findings from FMOLS, DOLS, FE-OLS, and MMQR estimators

as economic growth, health expenditure, CO_2 emissions, and sanitation, using a dataset from 2000 to 2018. The research utilised several econometric approaches such as CSD, slope homogeneity (SH), CIPS and CADF, FMOLS, FE-OLS, DOLS, Westerlund cointegration, and the newly developed method of moments quantile regression. The outcomes of the CSD and SH tests presented issues of homogeneity and CSD. Therefore, using first-generation approaches that do not consider both CSD and homogeneity will produce misleading outcomes. As a result, we utilised second-generation techniques. The outcomes of the Westerlund cointegration affirmed a long-run interrelationship between LE and its drivers (economic growth, health expenditure, CO_2 emissions, and sanitation). Moreover, the FMOLS and DOLS outcomes unveiled that economic expansion, sanitation, and health expenditure enhance LE, while CO_2 emissions reduce it in these Mediterranean nations. Furthermore, we applied the novel MMQR and the outcomes disclosed that in all quantiles (0.1–0.90), economic expansion, sanitation, and health expenditure enhance LE, but in all quantiles (0.1–0.90), CO_2 emissions dampen LE.

Policy direction

Various policy suggestions are proposed based on our outcomes. Firstly, authorities in Mediterranean nations should enact robust sustainability initiatives that lessen the strain on natural resources, including land, forests, air quality, and water. Because contamination has a negative influence on one's quality of life, it frequently obstructs the beneficial impact of economic expansion on LE. Studies have found that countries with better health have higher per capita production and can acquire more wealth than countries with deteriorating health. As a result, policymakers in these nations should implement effective environmental and public health measures that will pay off in the long run through improved health as a result of lower emissions of CO_2, as well as increased economic expansion and productivity. In addition to creating ecological degradation tracking systems and improving ecological regulations and laws, policymakers should engage in innovation and research to discover and create technology that will decrease environmental deterioration. Secondly, to achieve better economic expansion, manufacturing activities should strive to use environmentally friendly resources and technology, including renewable energy. Thirdly, because health and income spending have a beneficial impact on LE, healthcare spending must be raised in the budget. Lastly, to enhance LE in these nations, all individuals must have access to basic sanitation facilities and clean drinking water. In this context, collaborative efforts via public–private partnerships will be extremely beneficial. Another area where action is needed is to improve the quality of healthcare facilities and personnel. This entails more than just ensuring equipment availability; it also necessitates making the healthcare system more accountable to the public.

Caveat of the study and future direction

There are several significant limitations to the present study. For instance, the study only included a few control variables and neglected other potentially confounding variables such as physician-to-population ratios, literacy rates, and a variety of other health-related factors. Therefore, future studies should consider these variables. Lastly, future studies can replicate this research in other regions/blocs such as MINT, G7, BRICS, African nations, European Union, and North and South American countries.

Author contribution Tomiwa Sunday Adebayo collects data and interpret it. Mehrshad Radmehr wrote the methodology and literature review.

Data availability Data is readily available at the request of the corresponding author.

Declarations

Ethics approval This research complies with internationally accepted standards for research practice and reporting.

Consent to participate Not applicable

Consent for publication Not applicable

Competing interests The authors declare no competing interests.

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